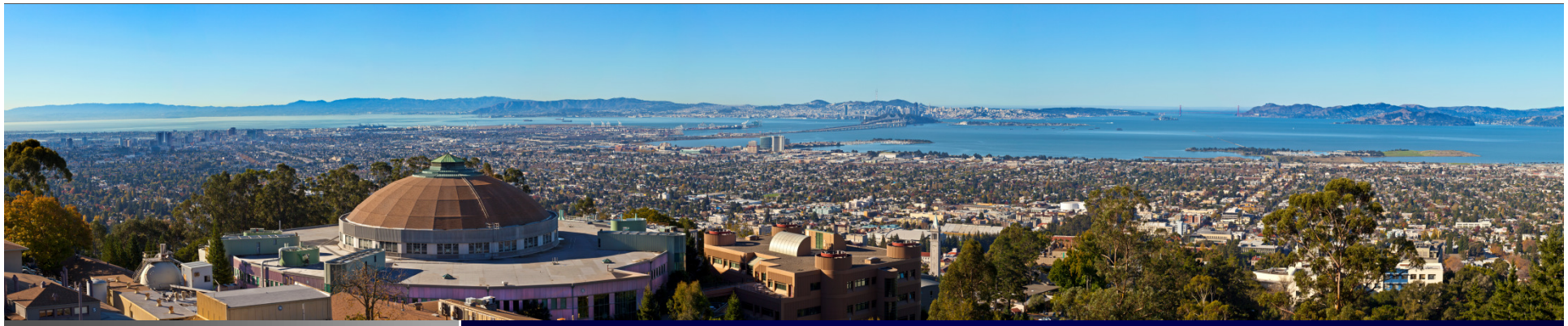


# LBNL Engineering Division

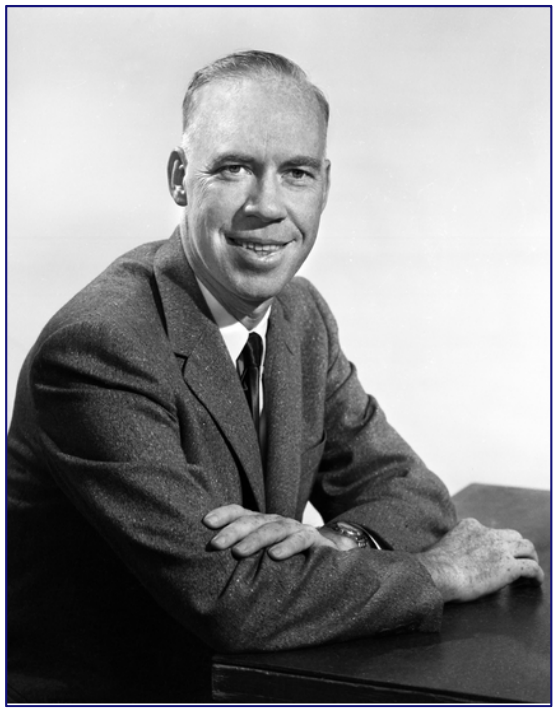
## – Yet Another Unfair Berkeley Lab Advantage

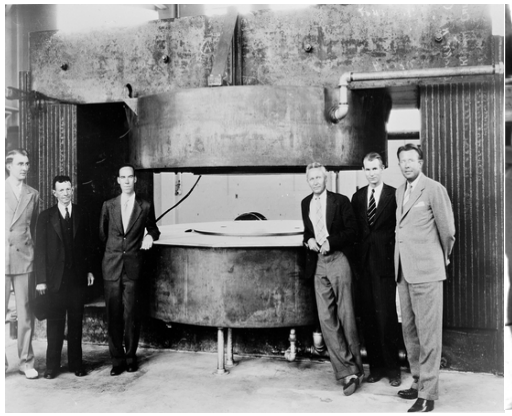
Kem Robinson
2 December 2011

# Lawrence Introduces Big Team Science

BERKELEY LAB

# Bill Brobeck
# — LBNL First Chief Engineer 1937-1957





60-inch cyclotron in construction

60-inch cyclotron vacuum chamber

*"Brobeck [is a] master of the confluence of engineering and physics, who transformed homemade toys into superb tools of the intellect, and helped open to human understanding the worlds of the atom and of subatomic particles."*

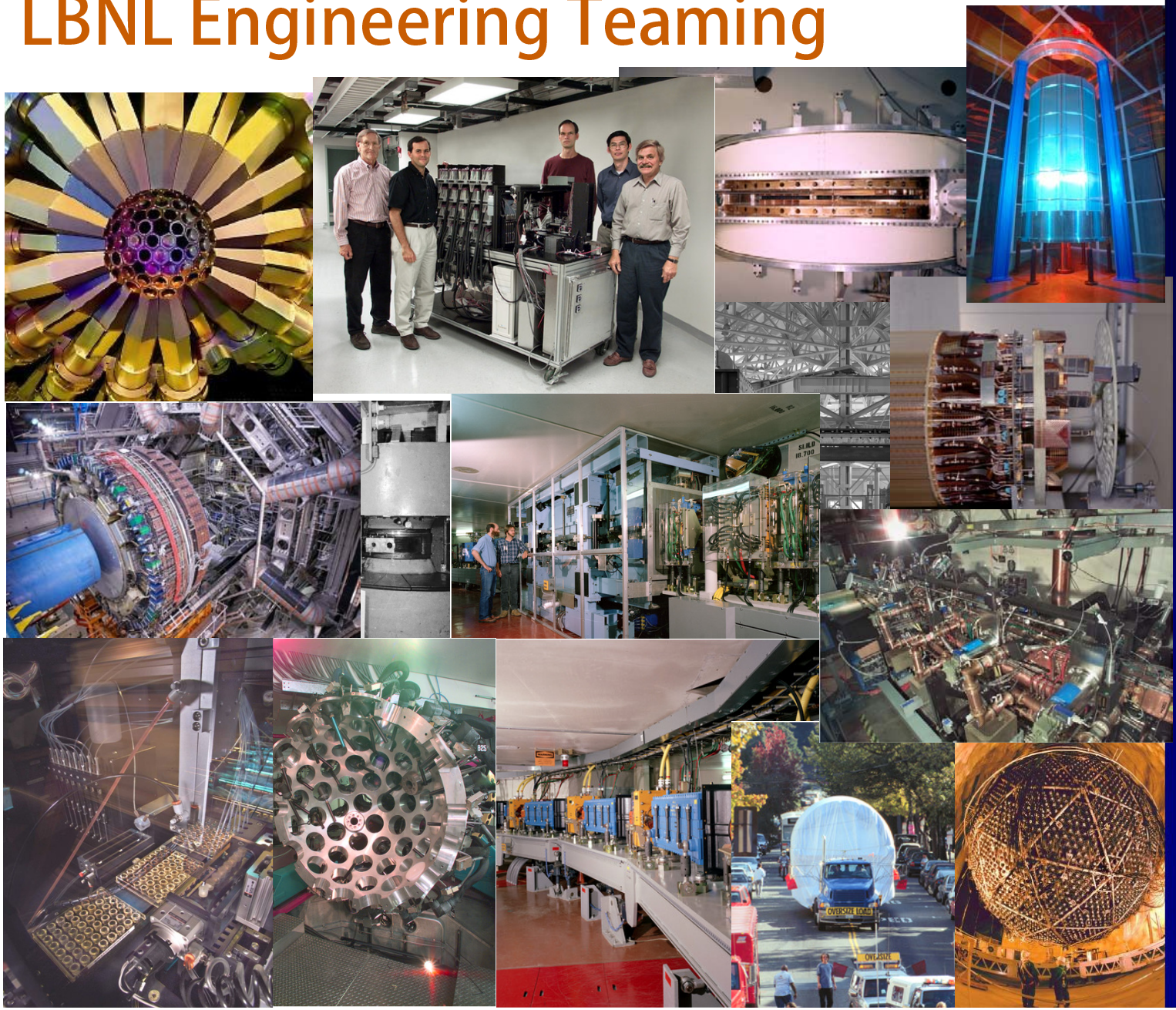
— Edwin McMillan, Nobel laureate, LBNL Director (1958 – 1972)

Alvarez Cloud Chamber

# LBNL Engineering

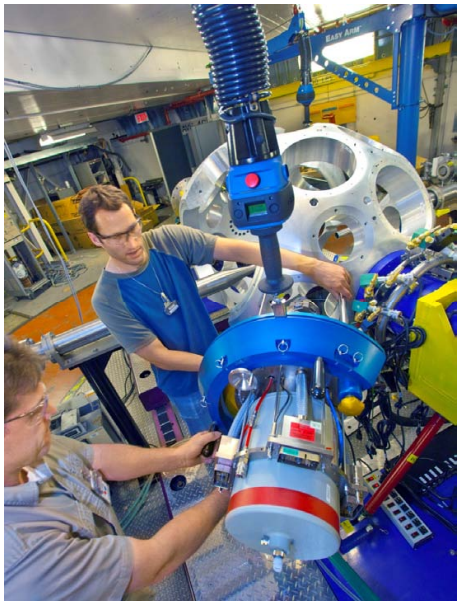
- Supports scientific endeavors through competent, accessible engineering focused on solutions developed through close interactions with researchers (value added)
- Enhances scientific potential through innovation in scientific apparatus and techniques (competitive advantage to researchers)
- Teamed with scientists since inception of laboratory
- Within Operations when with Brobeck established original incarnation
- Moved from Operations to General Sciences in 2004

# A Few Accomplishments involving LBNL Engineering Teaming



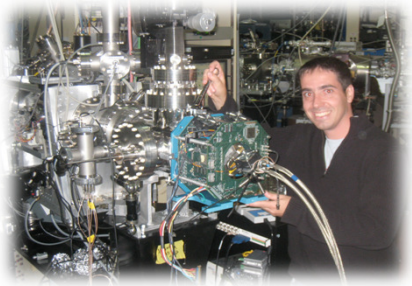

- Cyclotrons
- Bevatron
- HILAC
- Bevalac
- TPC
- ALS
- CDF
- DØ
- SNO
- BaBar
- SNS
- LHC
- ATLAS
- Bio-instruments
- Genome sequencing

# LBNL Engineering



The LBNL Engineering Division

- Full matrix organization
- Partners with scientific divisions to
  - Design
  - Engineer
  - Build
  - Integrate
  - Maintain and upgrade
- The next generation of complex instrumentation of all scales
- Specifically breakthrough instrumentation that will be required to advance world-class scientific exploration and discovery

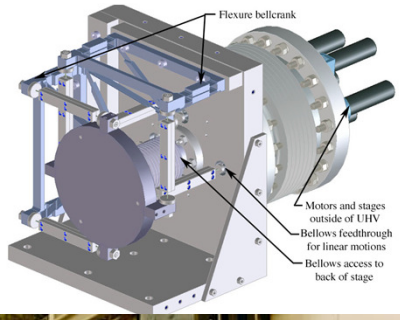


# LB L En ineerin Basic tructure

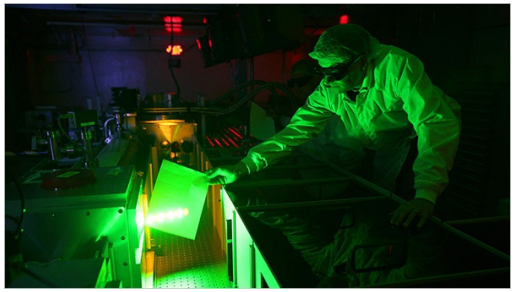
BERKELEY LAB

**Engineering Division**

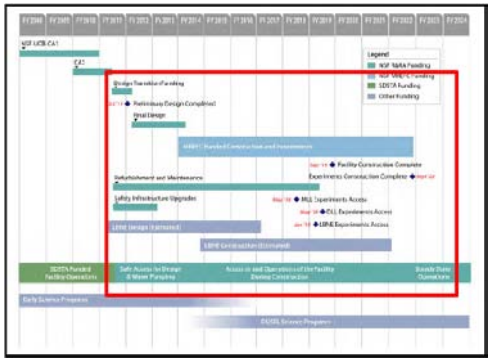
## Mechanical Engineering

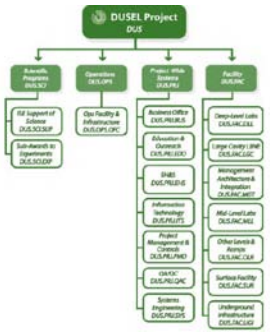



## Electrical, Software, & Instrumentation



## Operations / Project Mgmt & Controls



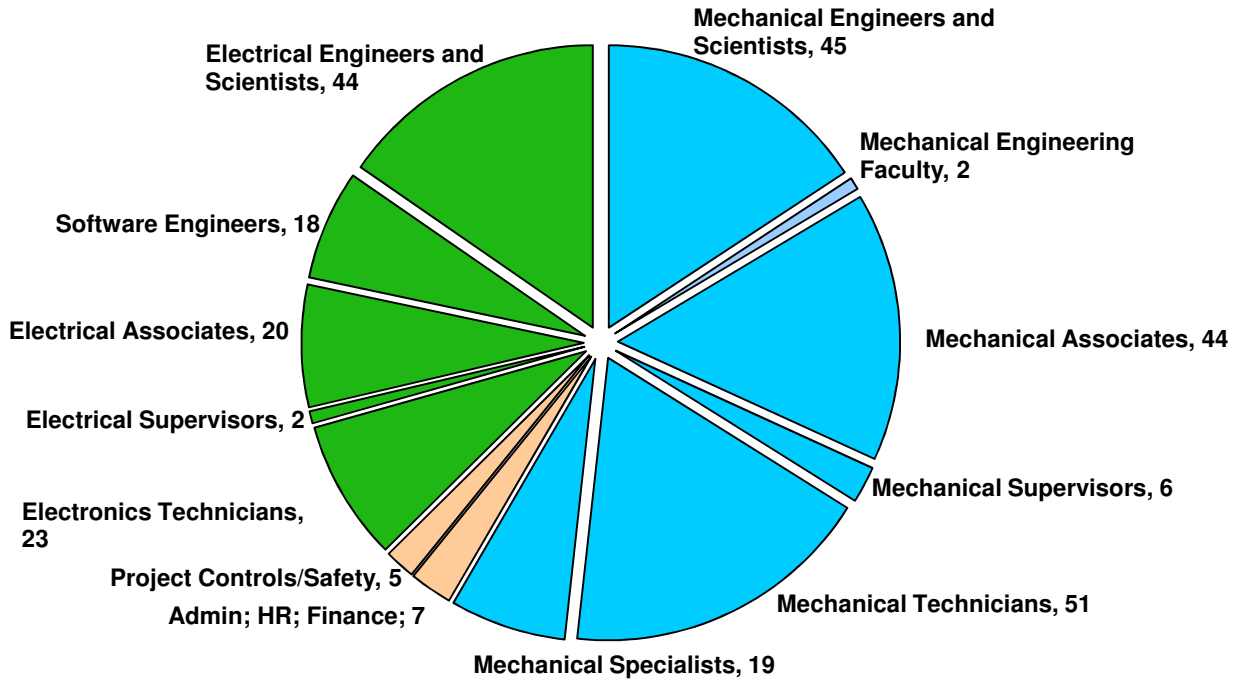


# LB L En ineerin — o re e?

## LBNL Engineering - A Snapshot of Our Team

**Electronics, Software & Instrumentation, 107**

**Mechanical Engineering, 167**




**Operations, 12**

286 Career Staff
- 78 PhD and Masters
- 151 degree holders

# LBNL Engineering ivision - Senior Personnel

| Name | Title | Email | Contact |
|---|---|---|---|
| Kem Robinson | Engineering Division Director | KERobinson@lbl.gov | 510.486.6237 |
| John Freeman | Deputy | JCFreeman@lbl.gov | 510.486.4255 |
| Ross Schlueter | Deputy<br>Mechanical Engineering | RDSchlueter@lbl.gov | 510.486.7405 |
| Henrik von der Lippe | Deputy<br>Electronics Engineering | HVDLippe@lbl.gov | 510.495.2327 |
| Russell Wells | Dept. Deputy<br>Mechanical Engineering | RPWells@lbl.gov | 510.486.7925 |
| Ken Chow | Design Engineering<br>ALS/ENG/DESIGN | KPChow@lbl.gov | 510.486.6051 |
| Shlomo Caspi | Design Engineering SUPERCON | S_Caspi@lbl.gov | 510.486.7244 |
| Stephen Holland | Semiconductor Detectors | SEHolland@lbl.gov | 510.486.5069 |
| Walter Barry | ALS – Electronics Engineering | Walter_Barry@lbl.gov | 510.486.6705 |

# LBNL Engineering ivision - Senior Personnel

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| Alex Ratti | Advanced Instrumentation | Aratti@lbl.gov | 510.486.5050 |
| Joseph Rasson | Mechanical Organization/Projects | JERasson@lbl.gov | 510.486.6450 |
| Rob Duarte | Small Projects | RMDuarte@lbl.gov | 510.486.7229 |
| Steve Marks | Magnetics | S_Marks@lbl.gov | 510.486.5828 |
| Sergio Zimmerman | Electronic Systems | Szimmerman@lbl.gov | 510.495.2964 |
| Will Waldron | Pulsed Power and Induction Linacs | WLWaldron@lbl.gov | 510.495.2347 |
| Jian Jin | Center for Systems Biology Engineering | Jjin@lbl.gov | 510.486.4633 |
| Guy Pulsifer | Central Shops Manager | GRPulsifer@lbl.gov | 510.486.4993 |
| Rafael Gomez-Sjoberg | Center for Systems Biology Engineering | RGomez@lbl.gov | 510.486.5729 |



BERKELEY LAB

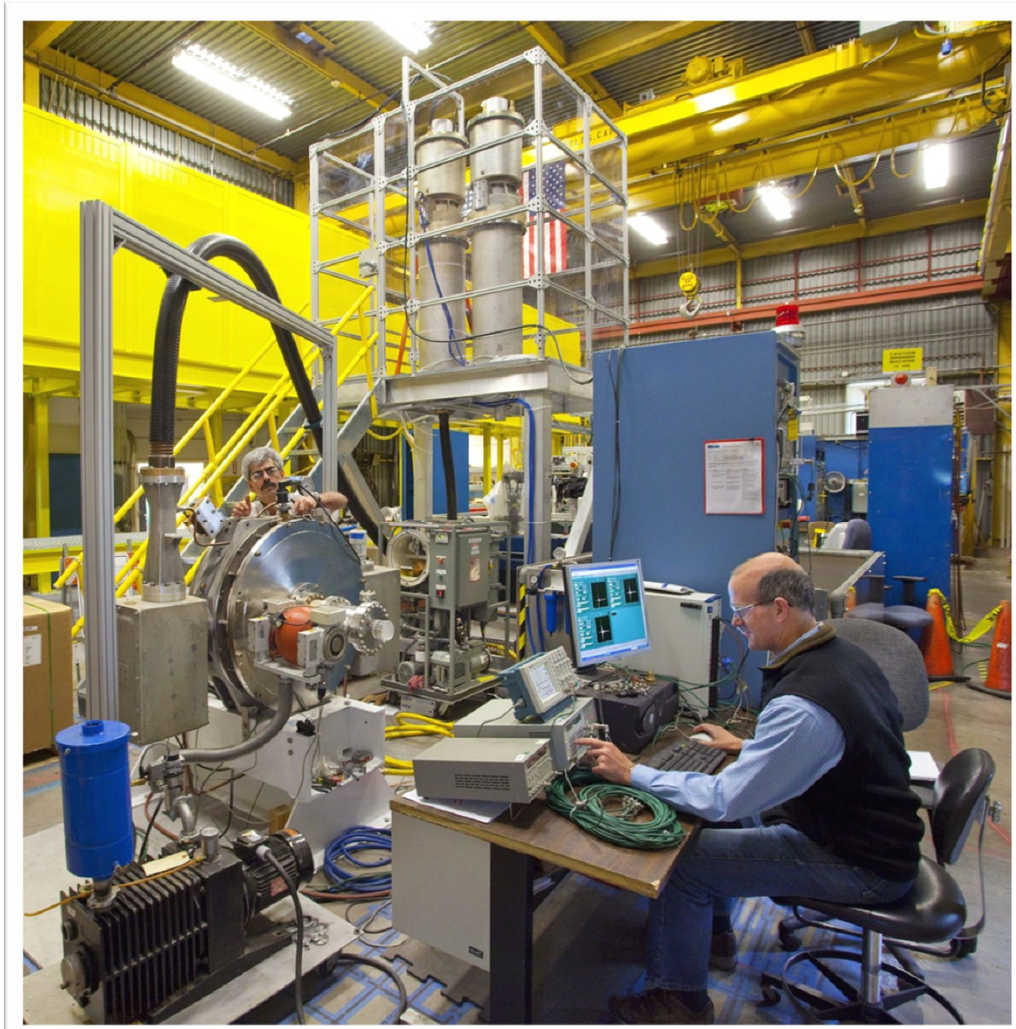
# SOME CURRENT ACTIVITIES / CAPABILITIES

BERKELEY LAB

# or ing it Engineering Division

## Electrical, Software & Instrumentation Capabilities

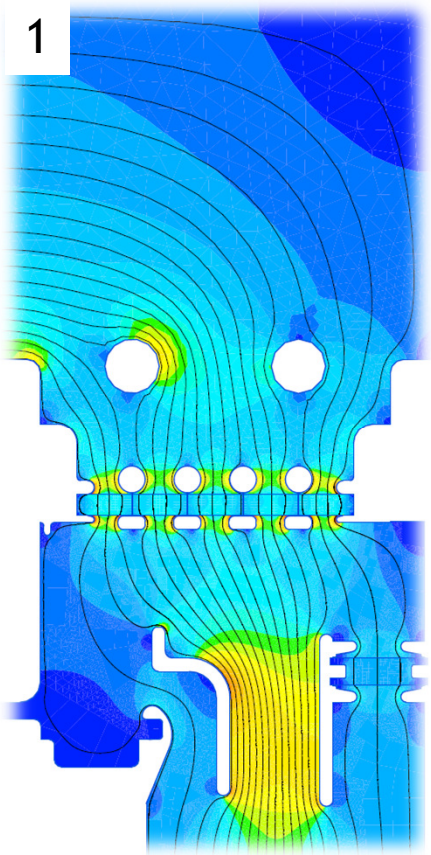
# Pulsed Power Engineering



- Power modulator design and fabrication for injectors, induction accelerators, high field pulsed magnets, and plasma sources
- Circuit and electromagnetic simulation and analysis
- Picture on left shows the NDCX-II test stand for tuning induction cell voltage waveforms (70ns, 250kV)

Contact: Will Waldron | WLWaldron@lbl.gov

# High oltage Engineering





- High voltage design and fabrication for injectors and accelerator structures
- Electrostatic simulation and analysis
- Picture 1 shows a 2D electrostatic simulation of the graded column for the NDCX-II injector
- Picture 2 shows the high voltage enclosure of the NDCX-II injector which is pulsed to 130kV

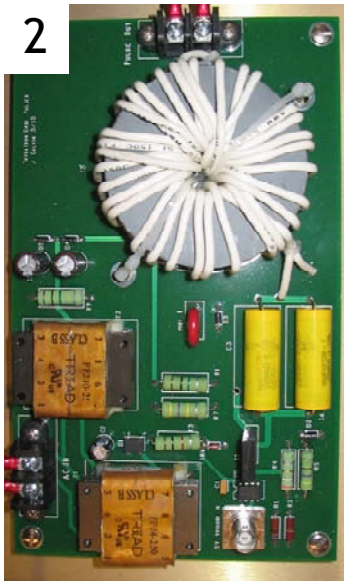
Contact: Will Waldron | WLWaldron@lbl.gov

# Solid State Power Modulators for Accelerator Applications

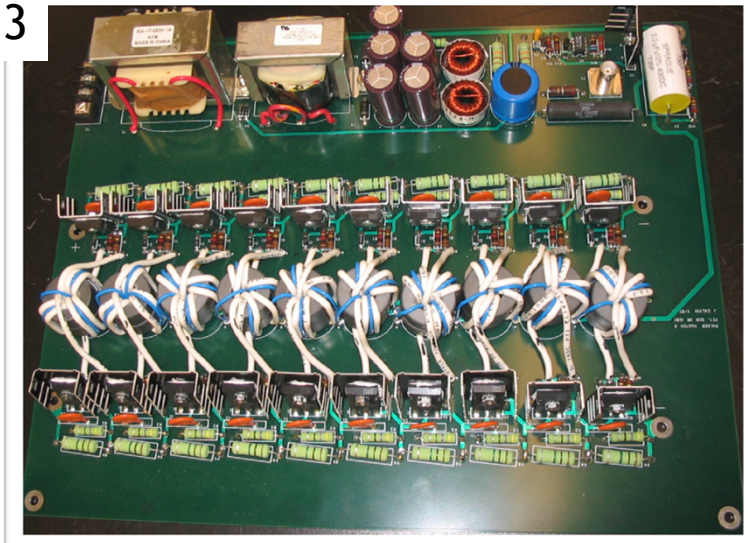
BERKELEY LAB

1

2



3



- SCR, MOSFET, and IGBT based designs
- Picture 1 shows the NDCX-II corrector coil pulser pc board
- Picture 2 shows the NDCX-II switch chassis trigger generator pc board
- Picture 3 shows the IGBT array pc board used for an ion source on a homeland security project

Contact: Will Waldron | WLWaldron@lbl.gov

# High Current Pulsers for 3T N CX-II Solenoids

- 30 pulsers have been fabricated and are in the process of being installed in the hi-bay of Building 58 for the initial configuration of NDCX-II
- 25kJ stored energy
- 5kV
- 10kA

Contact: Will Waldron | WLWaldron@lbl.gov

# Semiconductor  etector Lab

BERKELEY LAB

Thin-film deposition

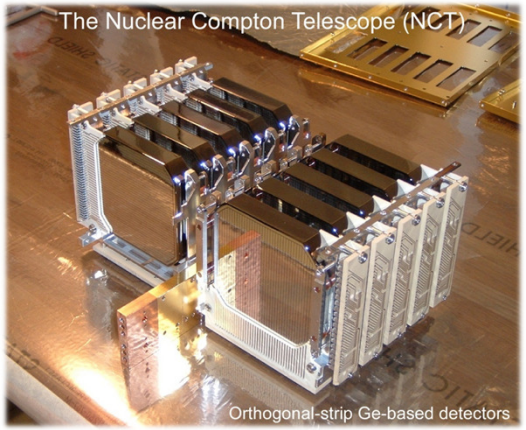
Chemical processing, photolithography, wire bonding

Detector characterization

Infrastructure and expertise for the development and production of semiconductor-based radiation detectors and detection systems

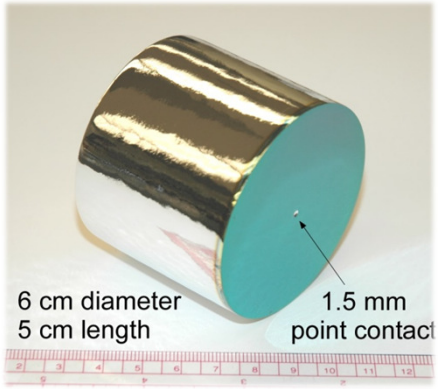
Contact: Sergio Zimmerman | SZimmerman@lbl.gov

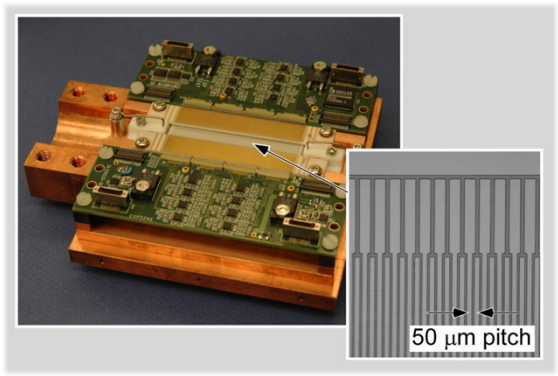
# Semiconductor  etector Lab



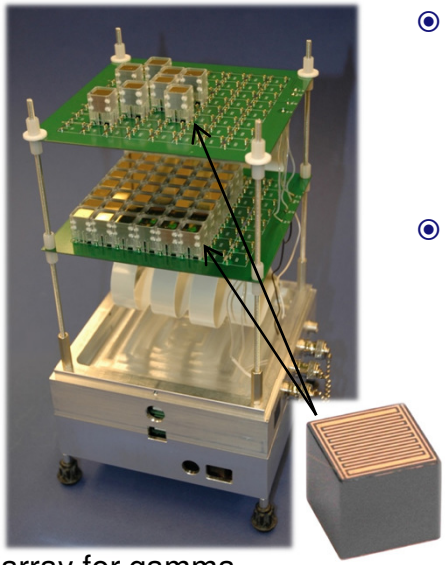

Ortho-strip Ge array for gamma tracking, imaging, and spectroscopy

Point-contact Ge for low-noise spectroscopy with multi-site event rejection




Strip Ge for light sources



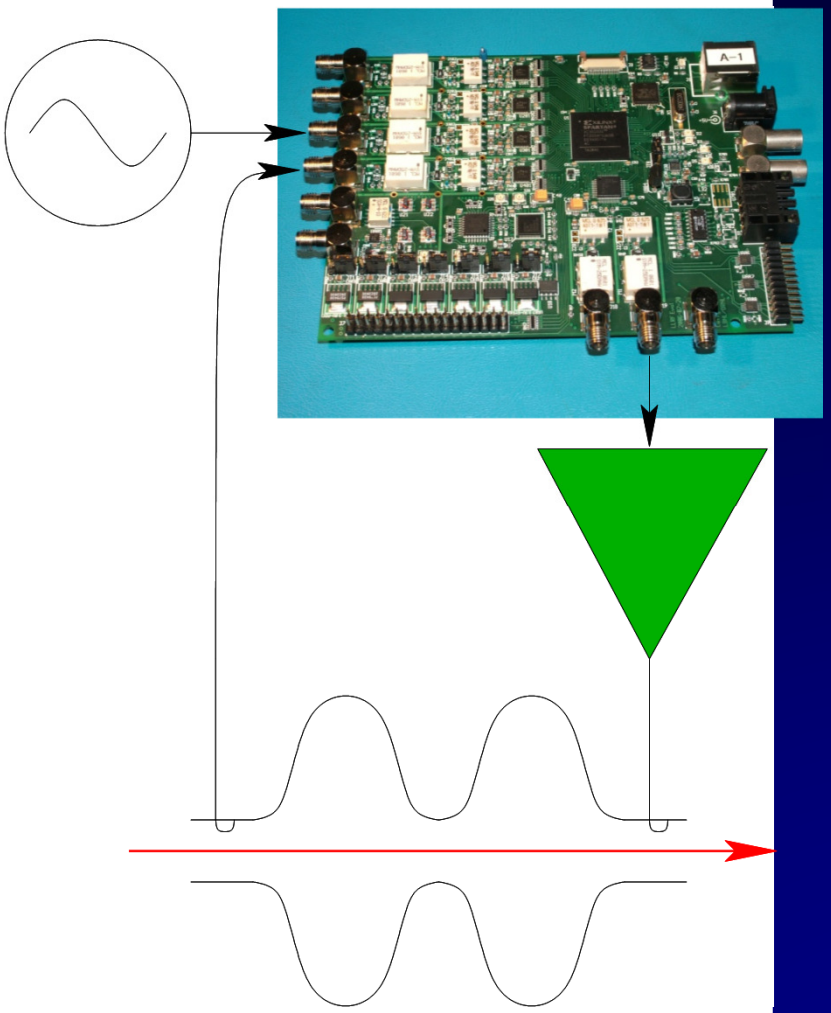
CdZnTe array for gamma imaging and spectroscopy

- **Facilities:** class 100 clean room, class 10,000 processing and testing area, mechanical processing area
- **Processes:** mechanical and wet chemical processing, thin film deposition, photolithography, wire bonding, detector characterization
- **Detector materials:** Ge, CdZnTe, and Si
- **Technologies:** diffused, implanted, surface barrier, and amorphous contacts; strip, orthogonal strip, point contact, and other unique configurations
- **Application areas:** nuclear science, space science, x-ray light source science, homeland security, nonproliferation, medical imaging

Contact: Sergio Zimmerman | SZimmerman@lbl.gov

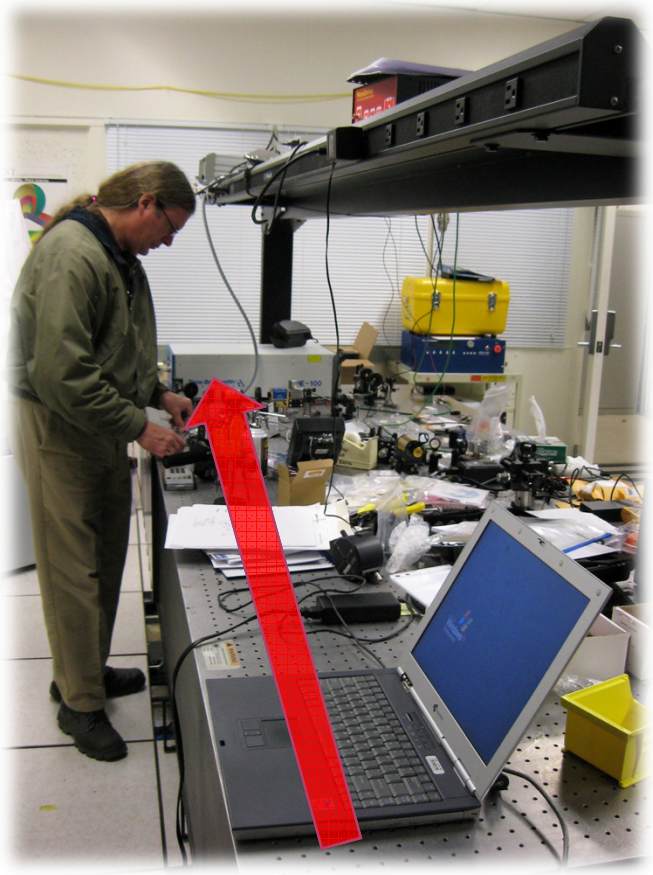
# RF Controls (aka LLRF)

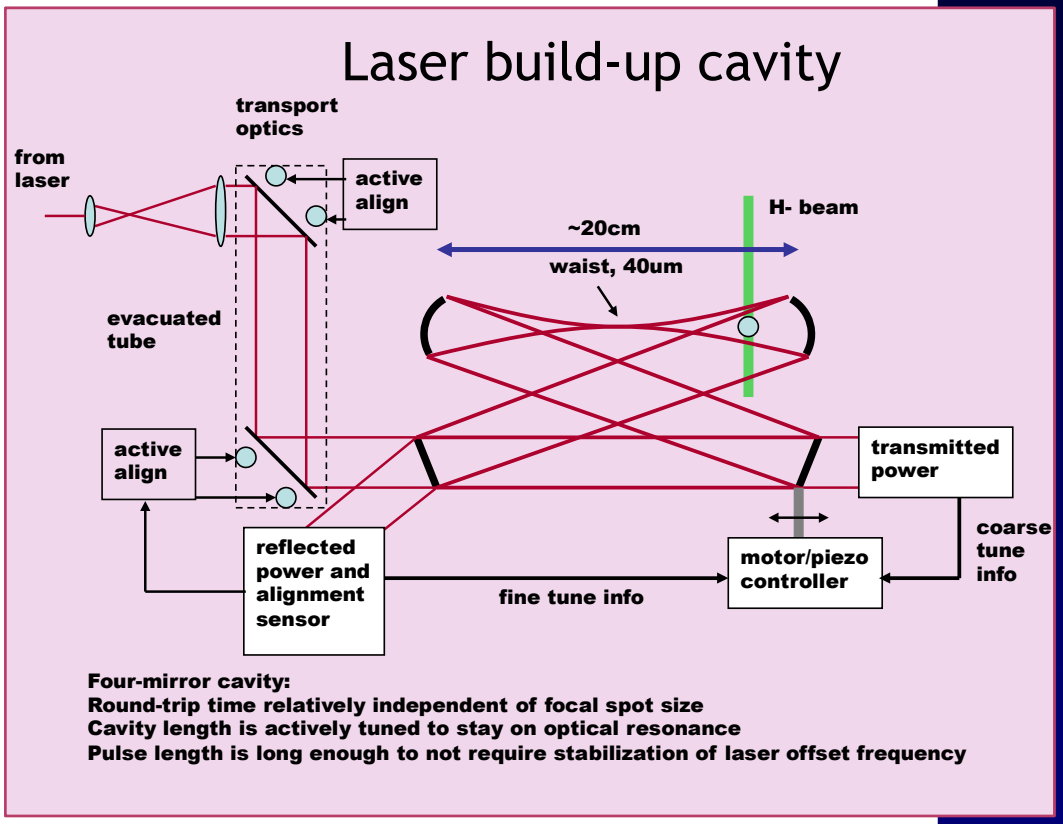
- Pioneered implementation to scale of fully digital RF controls
  - Operating in SNS since 2002
  - Reaches 0.01%, 0.01 deg stability
- Leverages advances in FPGA technology
- Implementing in
  - Rings and Linacs
  - Pulsed and CW



Contact: Alex Ratti | ARatti@lbl.gov

# Power Laser Technology



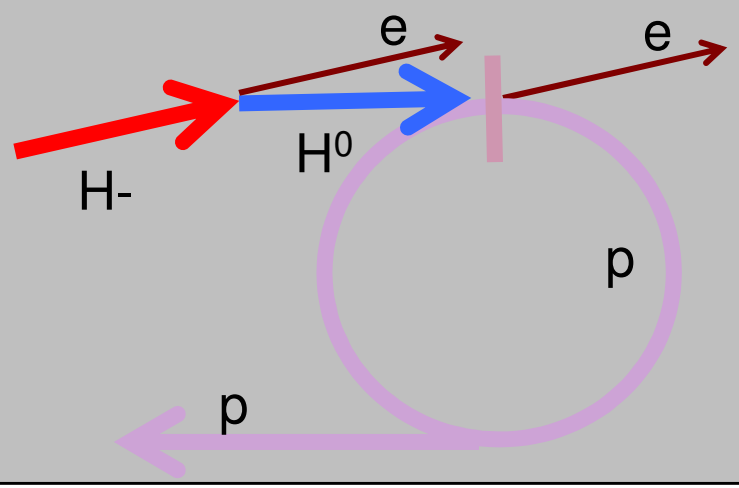



New Nd:YAG laser system being assembled for tests.

Contact: Alex Ratti | ARatti@lbl.gov

# Power Laser Technology

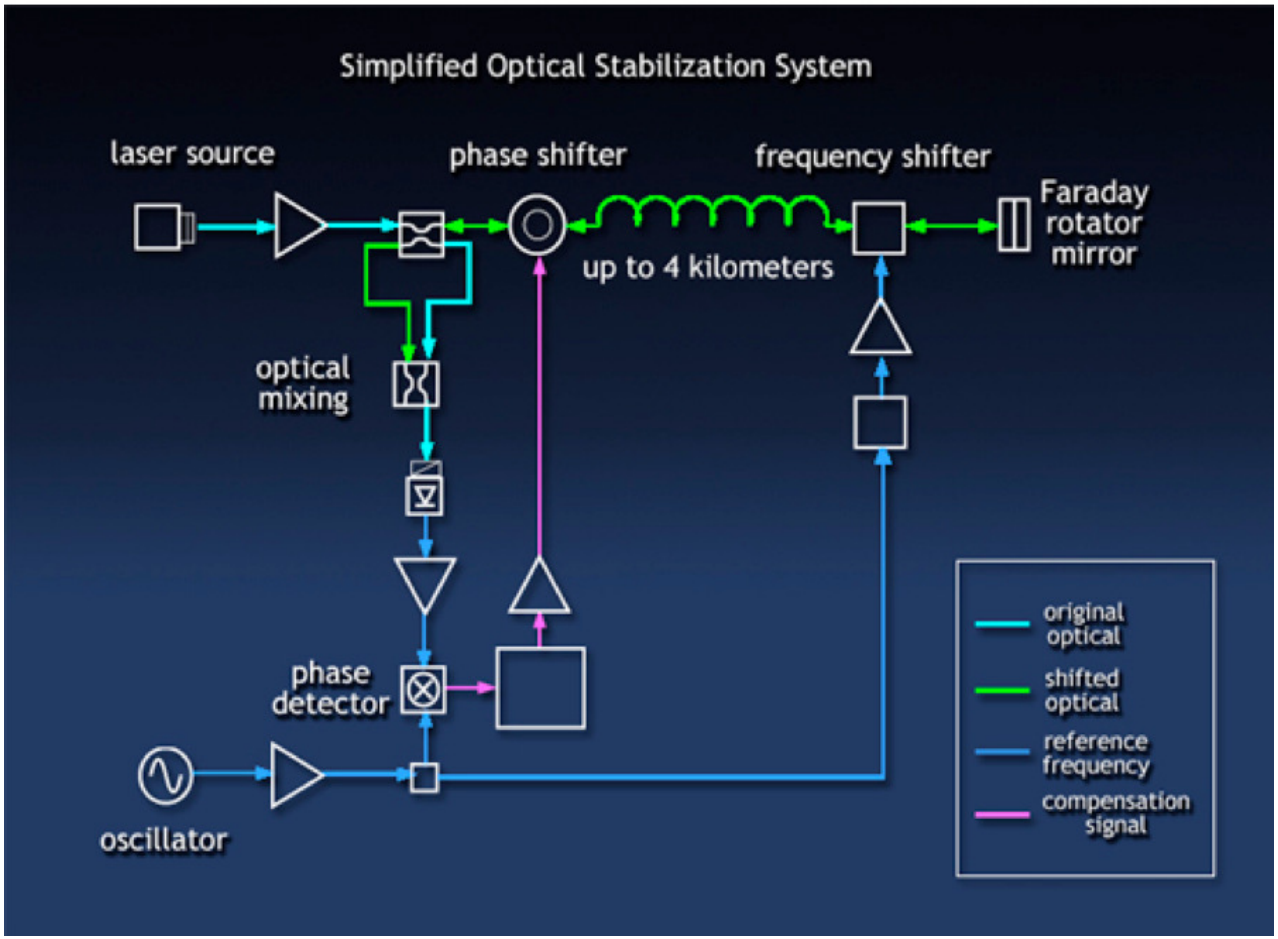
- Charge exchange injection is used for high intensity accumulation in proton synchrotrons
  - Accelerate H- beams
  - Remove first electron via Lorentz stripping (magnetic field)
  - Remove second electron with carbon foil




- Laser wires
  - Non-invasive beam diagnostics are a key element to monitor high intensity $H^-$ beam
  - Destructive beam monitoring methods cannot be located nearby SCRF
- Laser-assisted stripping
  - Survivability of stripping foils over 1 MW beam power is uncertain
  - Use lasers to excite $H^0$ to allow Lorentz stripping
- Laser choppers
  - Use lasers to photo-dissociate. Allows further flexibility in beam patterns. Use in combination with deflecting chopper.
- Key Applications
  - NGLS Seed Lasers

Contact: Alex Ratti | ARatti@lbl.gov

# Ultra Stable Timing and Synchronization (1)




Contact: Alex Ratti | ARatti@lbl.gov

# Ultra Stable Timing and Synchronization (2)

LBNL's Sync Head in FERMI@ELETTRA tunnel

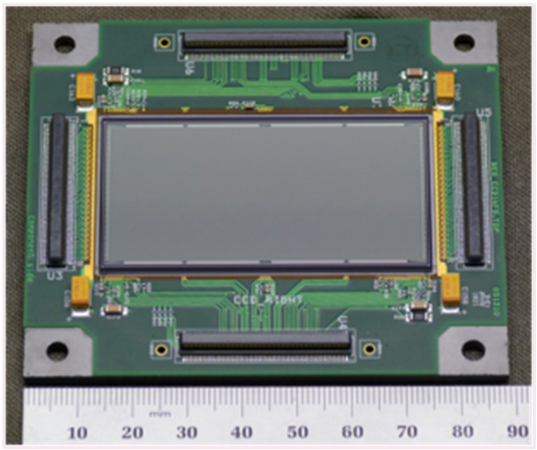
- Leverages optical technology and integrates it with advanced digital controllers
- Demonstrated fs-scale stability over kms of fiber
- Enables science in LCLS and FERMI@ELETTRA FELs
  - Essential to NGLS' success
- Key Applications
  - NGLS Timing and Synchronization

Contact: Alex Ratti | ARatti@lbl.gov

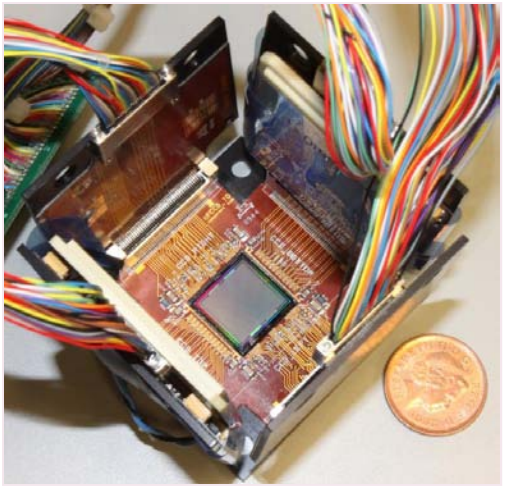
# Semiconductor  etectors — Fast CC  s

BERKELEY LAB

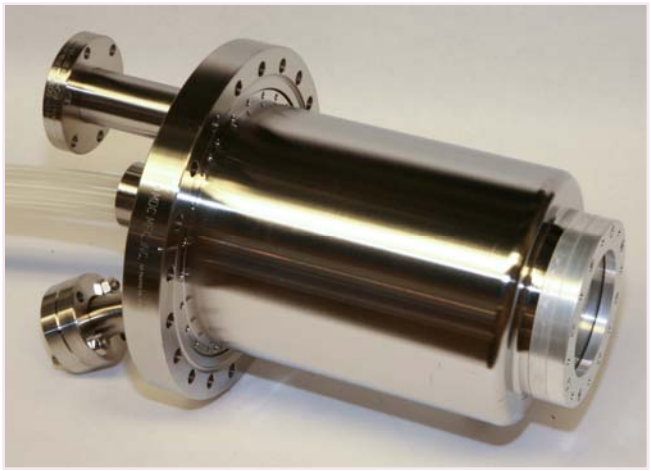
1M Pixel Frame Store Fast CCD



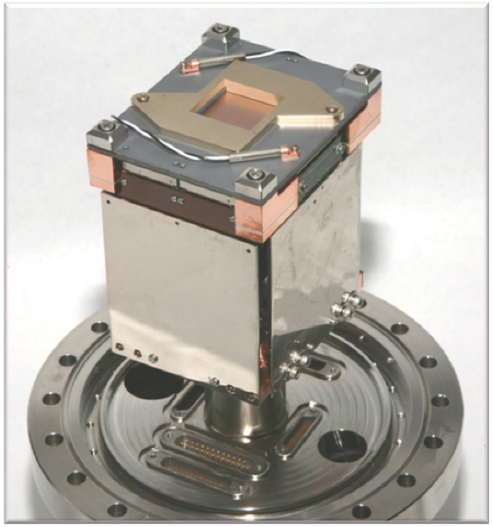
fCCD & Custom Readout Circuits



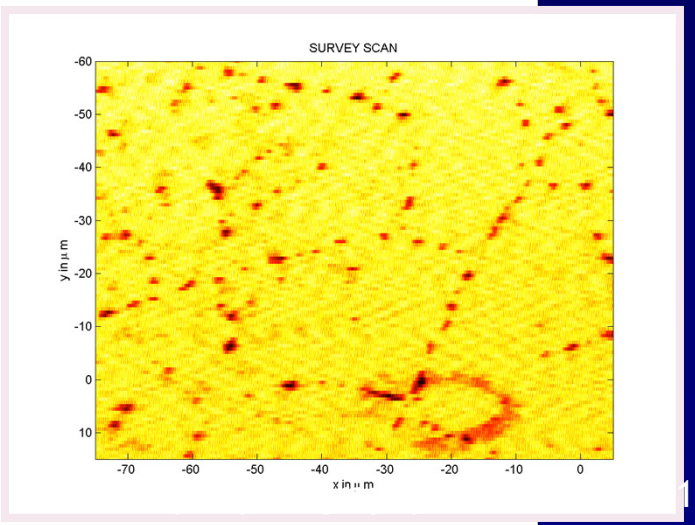
- Innovative and creative design and fabrication team
- Deliver engineered solutions to complex technical problems with critical design requirements
- Successful deployments at ALS, APS(ANL), & LCLS(SLAC)



UHV Ready fCCD Camera Head



Compact Fast CCD Assembly



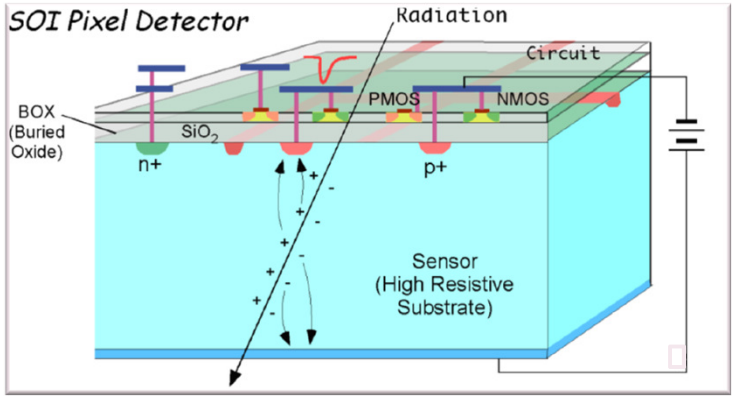

Contact: Henrik von der Lippe | HVDLippe@lbl.gov

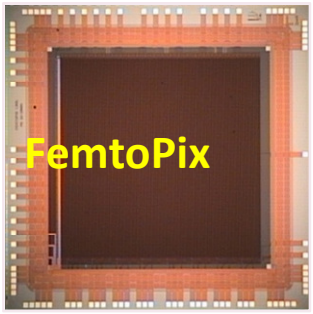
# Semiconductor  etectors - C  S

BERKELEY LAB

## Silicon On Insulator (SOI) R&D

Integration of CMOS electronic and high-resistivity substrate – potential for small pitch pixel sensors with high density, full CMOS readout



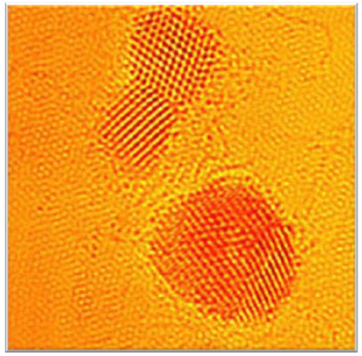



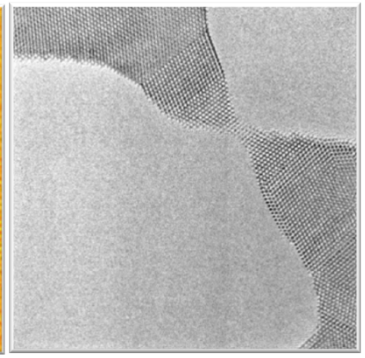

- **FemtoPix chip**: soft X-ray detector for ALS camshaft bunch femtoslicing
- 192×192 pixels, 17.5 µm pitch
- 4000 fps readout

## CMOS Active Pixel Sensors

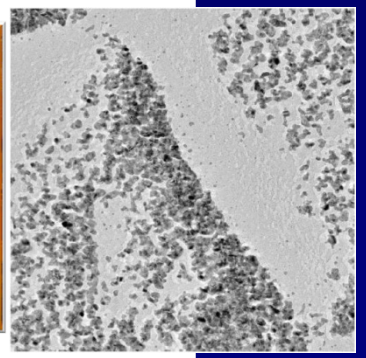
Developed in collaboration with Gatan Inc, UCSF and HHMI

In use on the TEAM Microscope at NCEM



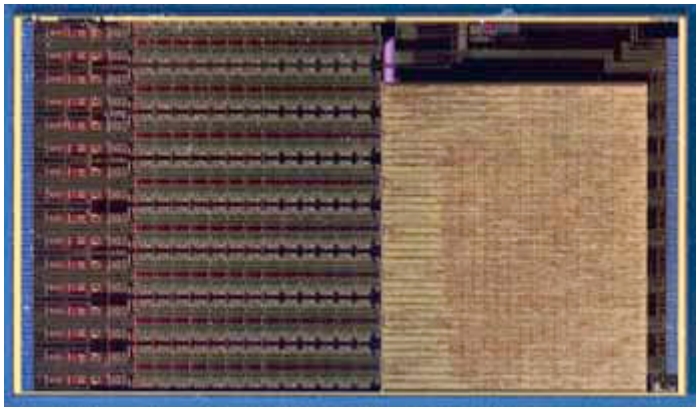
400 Mpixels/sec

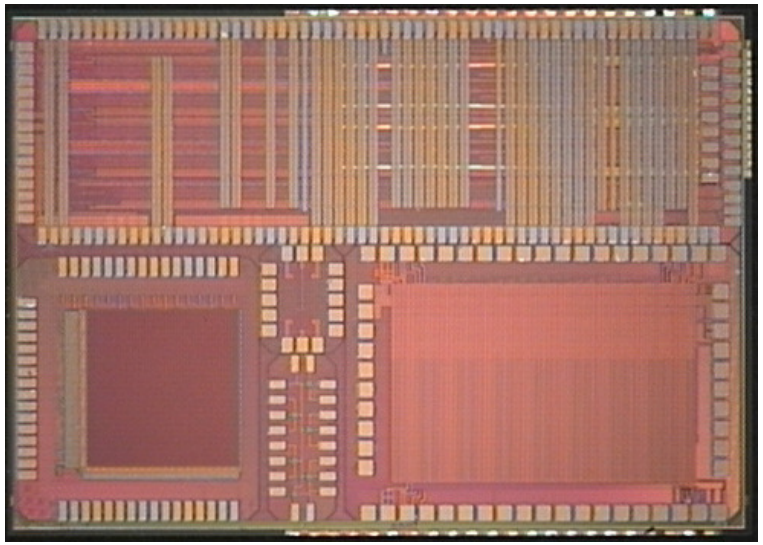
6,400 Mpixels/sec

Contact: Henrik von der Lippe| HVDLippe@lbl.gov

# Application Specific IC design



FCRIC 0.25um

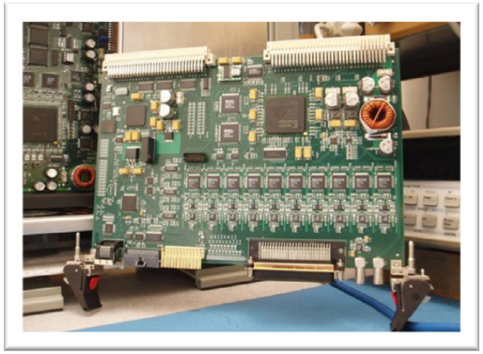


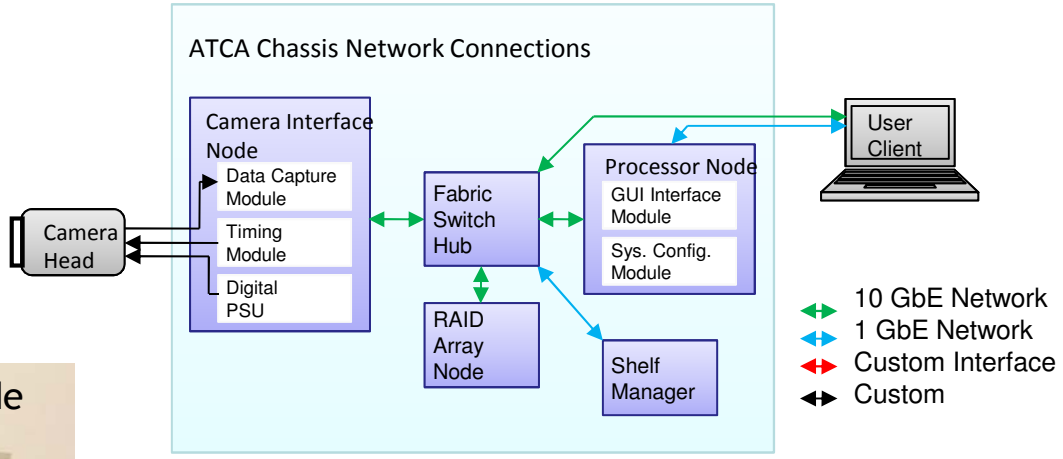
65nm MPC

- Specializing in mixed mode custom IC design
- Experience in broad range IC technology (SOI, High Voltage, 65nm – 3um)
- Detector readout
- IC design for extreme environment
- Ultra low noise analog front end
- Active Pixel Array for electron detection
- Silicon photo multiplier readout
- State of the art CAD tools for mixed mode IC design

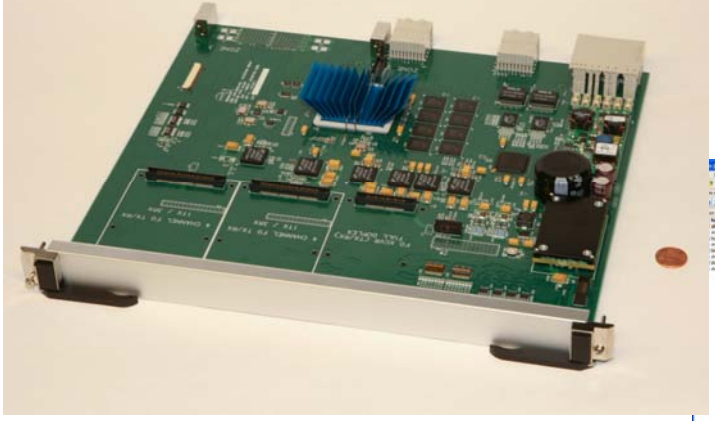
Contact: Henrik von der Lippe| HVDLippe@lbl.gov

# High Speed ata Acquisition ( A )

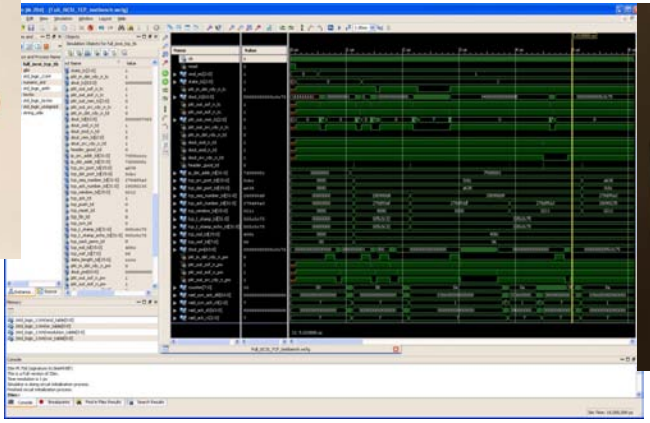





Camera Interface Node – ATCA Blade



- Custom LBNL design for ATCA platform
- Interface to 10GbE ATCA Fabric developed in EG Detector Group
- 14 layer, high speed PC board designed using Mentor Graphics CAD tools
- Custom FPGA firmware modules coded, simulated and synthesized using ModelSim and Xilinx ISE CAE design tools



Firmware design and simulation

ATCA based DAQ System

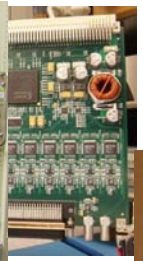
Contact: Sergio Zimmerman | SZimmerman@lbl.gov

# GRETINA — Ge Crystal Gamma Ray Detector

BERKELEY LAB

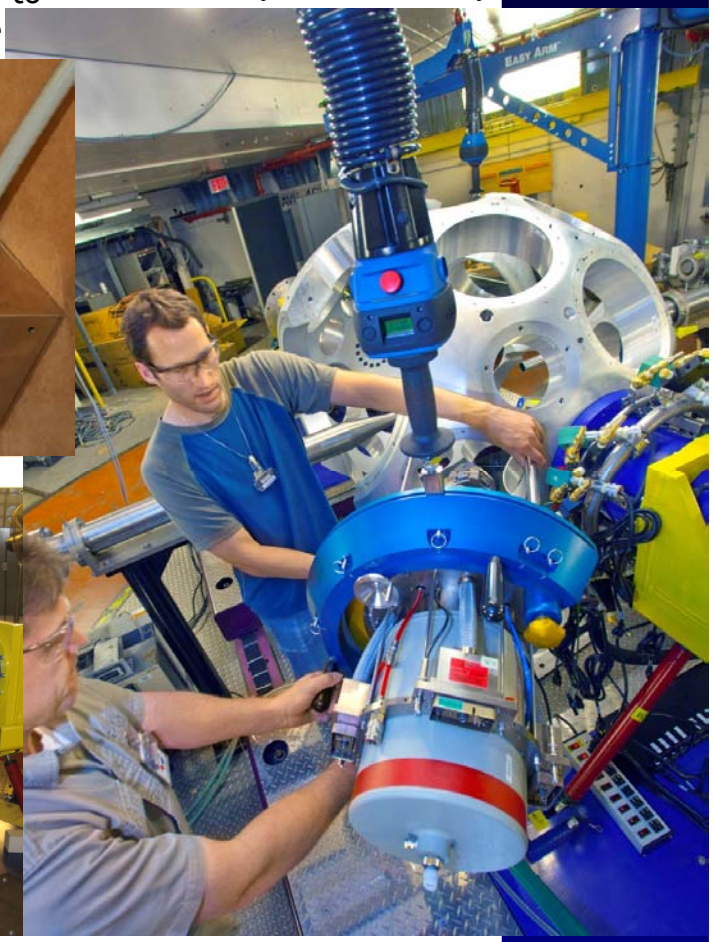
## EG/Nuclear Science Collaboration

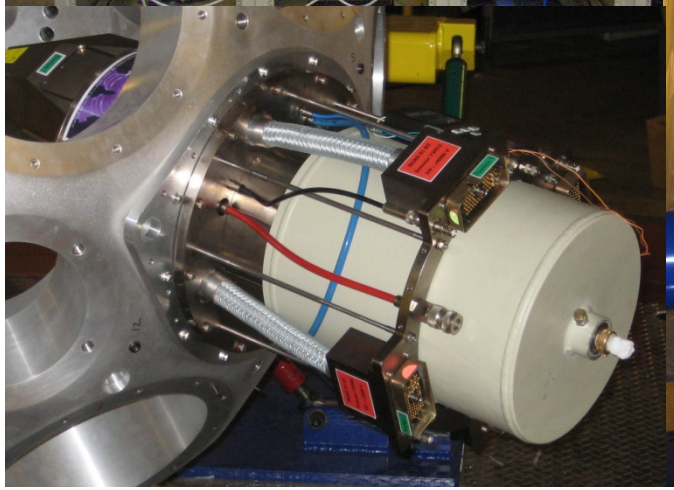
GRETINA Readout DAQ System

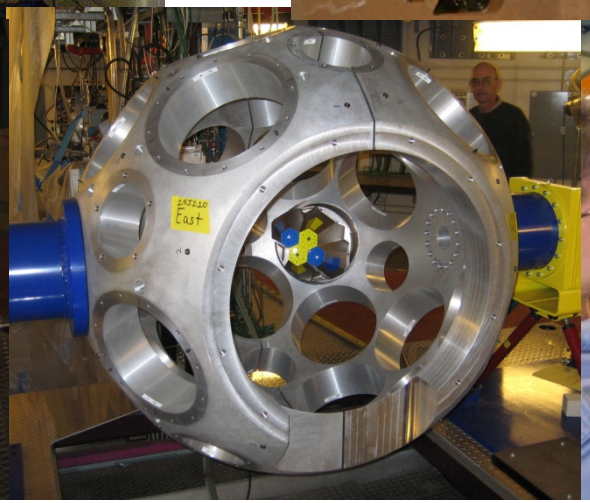


Custom Detector to DAQ Interface

Detector System Assembly



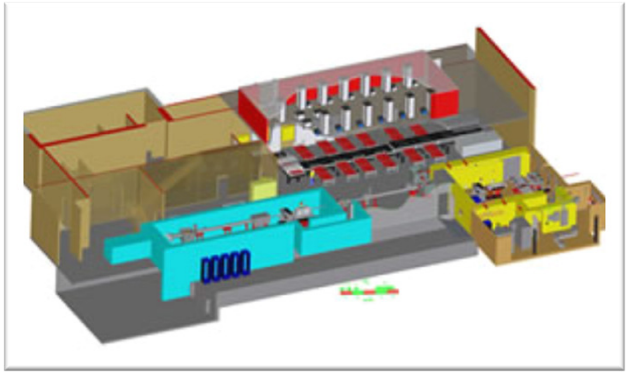




**Detector & Mechanical Mounting Structure**

Contact: Sergio Zimmerman | SZimmerman@lbl.gov

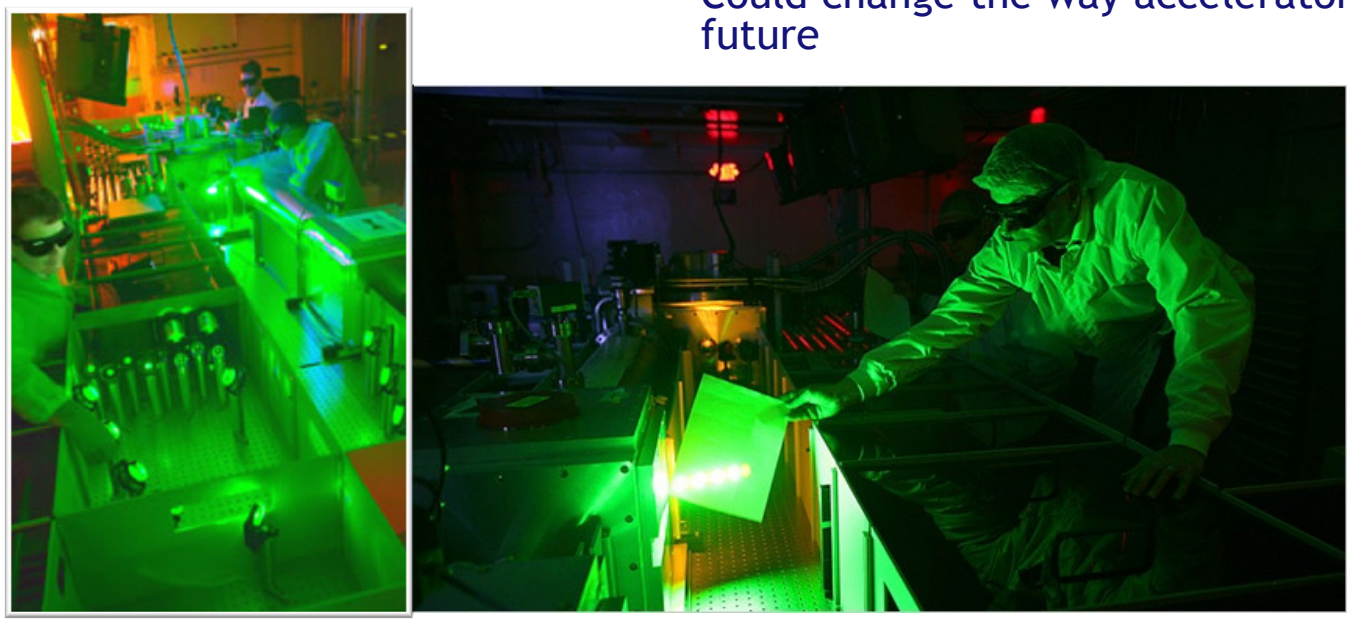
# BeLLA — (Berkeley Lab Laser Accelerator)



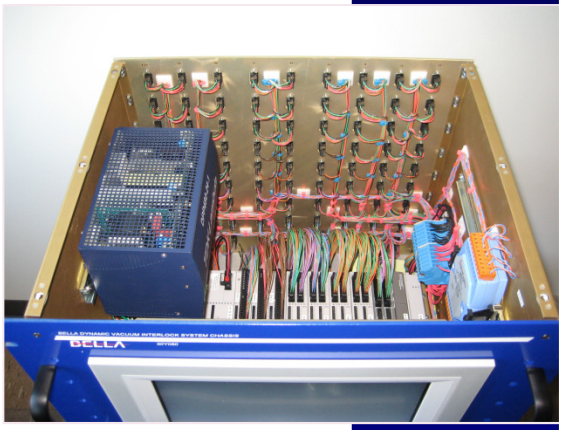
Model of Experiment Hall

## EG/AFRD Collaboration

- Create an experimental facility to advance the development of laser-driven plasma acceleration
- Ability to use laser light to accelerate an electron beam to 10 GeV in a distance of about 1 meter
- Potential to dramatically reduce the size, cost energy usage and environmental impact of future accelerators
- Could change the way accelerators are built in the future



Proof of Concept Beam Testing in the Laser Lab

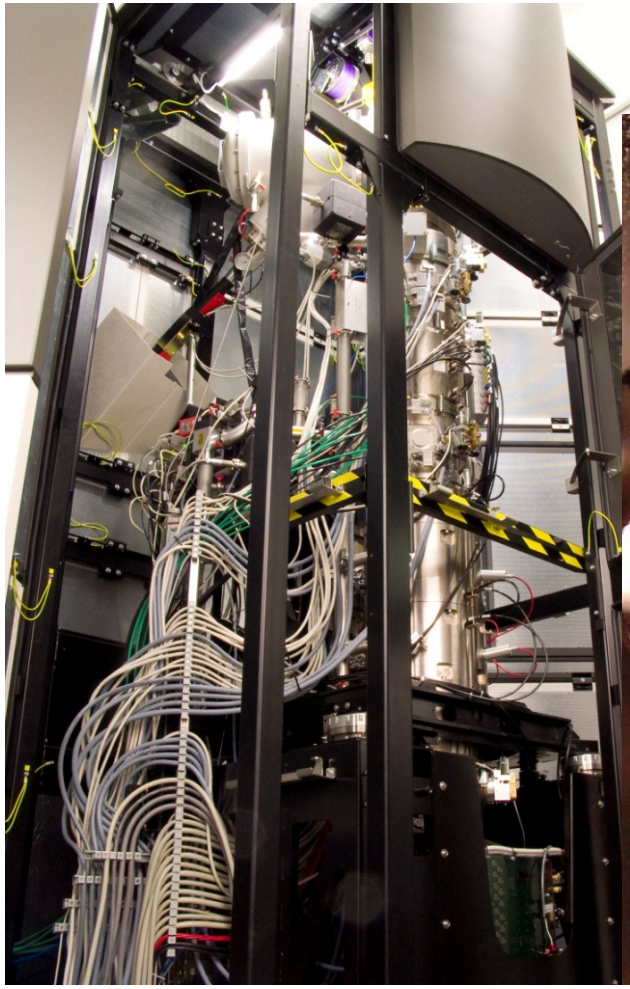


Custom Designed Safety Control System Assembly

Contact: Sergio Zimmerman | SZimmerman@lbl.gov

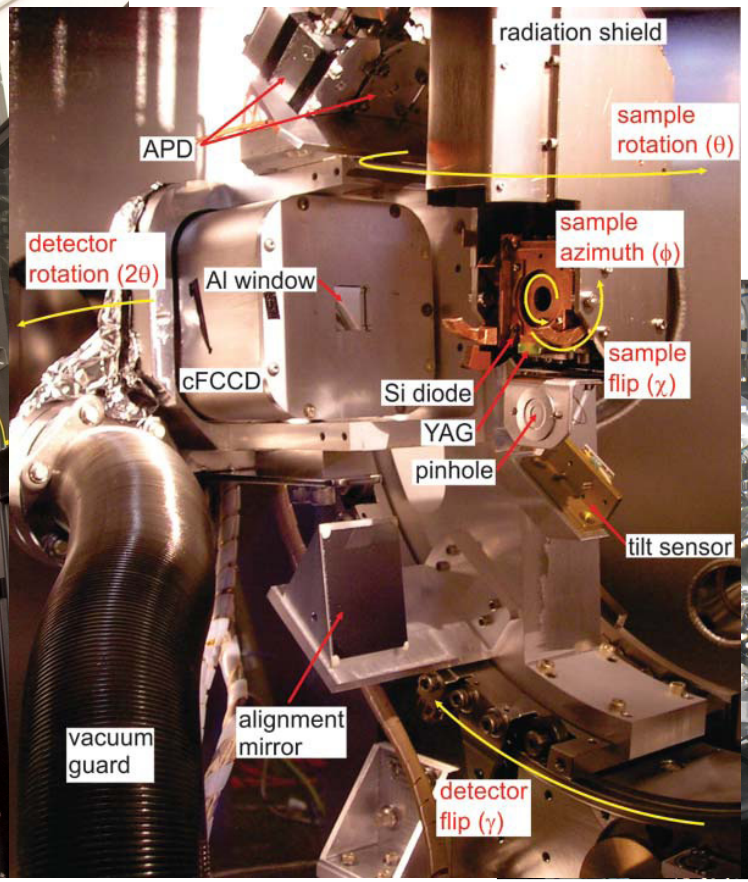
# TEA , ALS LCLS Collaborations

Custom DAQ Electronics deployed on the TEAM Microscope @ NCEM

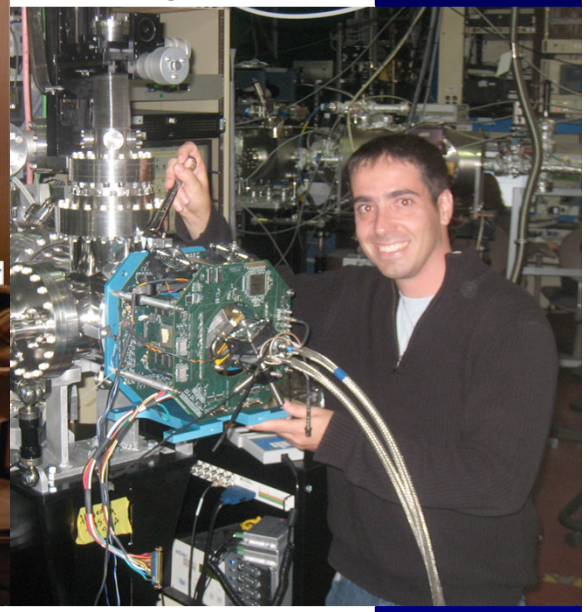


- History of successful collaborations with scientists at DOE user facilities

cfCCD in the RSXS Chamber @ LCLS

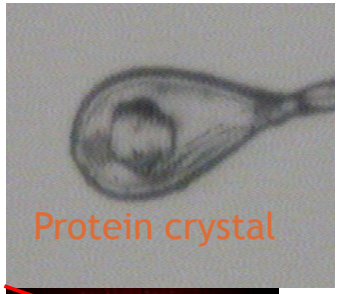


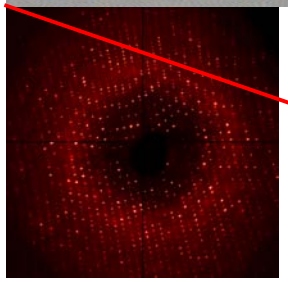

cfCCD on BL 9.0.1 @ ALS



Contact: Kem Robinson | KERobinson@lbl.gov

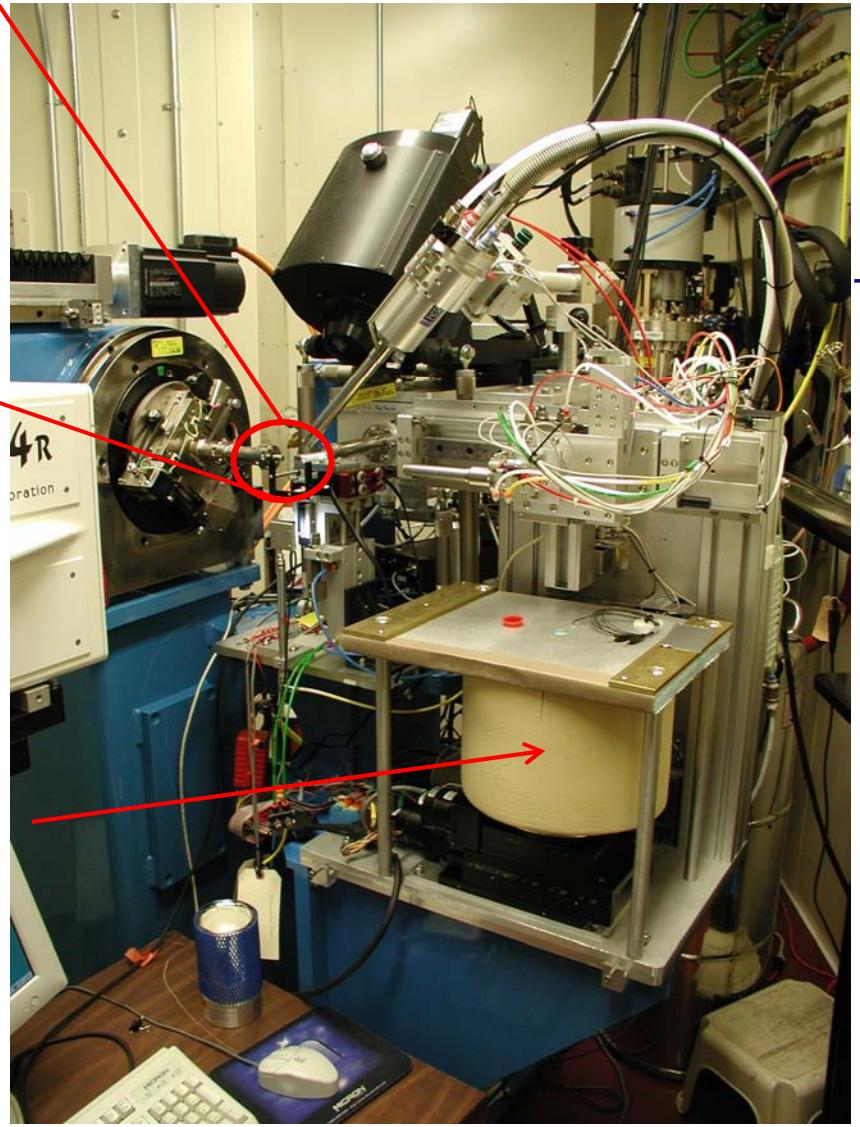
# Robotics/Systems instrumentation



X-ray diffraction image

$LN_2$ dewar with 64 crystals



**Automated protein crystal x-ray diffraction screening robot at the ALS.**

To enable high throughput structure biology, LBNL scientists and engineers developed several robotic systems to address rate-limiting steps in the pipeline. This robot fetches protein crystal from a LN2 dewar, mounts it on goniometer with xyz stage, aligns it to x-ray beam and takes a diffraction image to determine its quality. It increases sample throughput, data quality and eliminates the need for operator to change sample.

R&D 100 AWARD WINNER

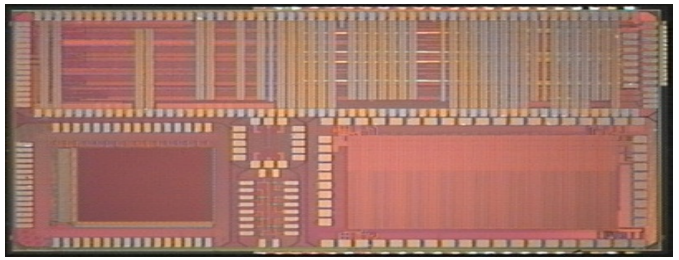
Contact: Jian Jin | JJin@lbl.gov



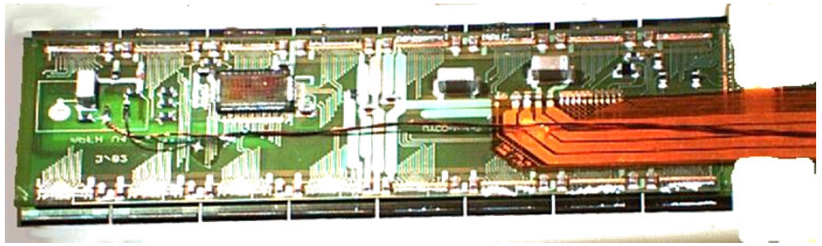
BERKELEY LAB

# Capabilities

- Application specific integrated circuits



- Semiconductor detector and instrumentation



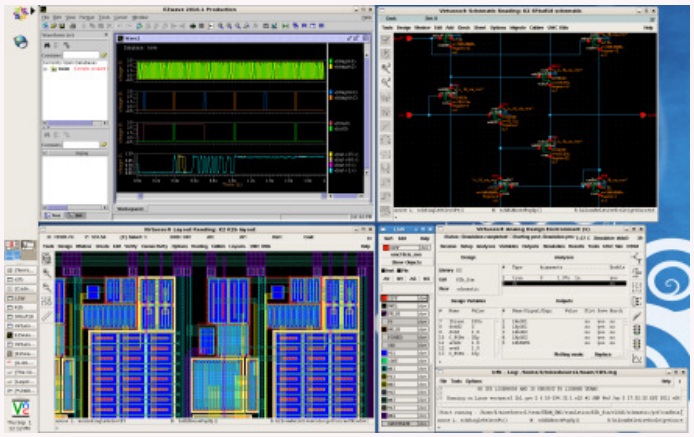
Contact: Henrik von der Lippe| HVDLippe@lbl.gov

# LBNL Engineering — A Snapshot
# Institutional Infrastructure (1)

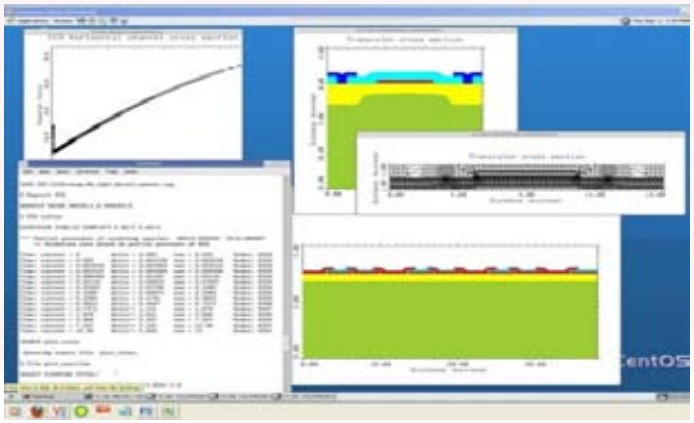
BERKELEY LAB

**Software Systems**

- High-End IC CAD



- High-End Detector modeling tools



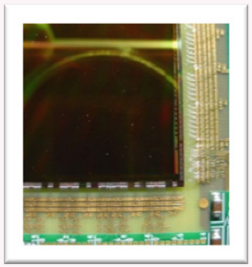
Contact: Sergio Zimmerman | SZimmerman@lbl.gov

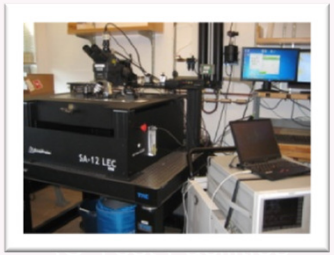
# LBNL Engineering — A Snapshot
# Institutional Infrastructure (2)

## Electronics & Detector Fabrication

- Wire Bonders

- IC Probe station



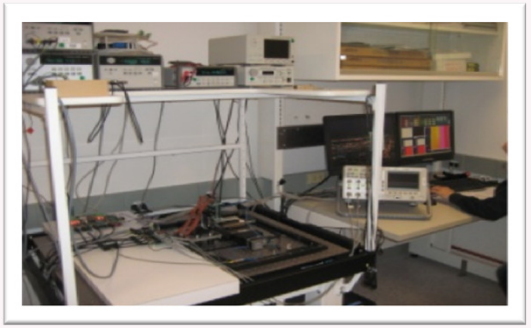


- Flip chip bonder

## Electronics & Detector Fabrication

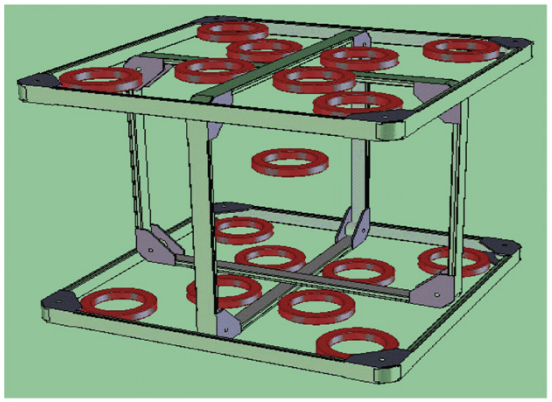
- Surface mount electronics assembly

- Detector system testing



Contact: Henrik von der Lippe | HVDLippe@lbl.gov

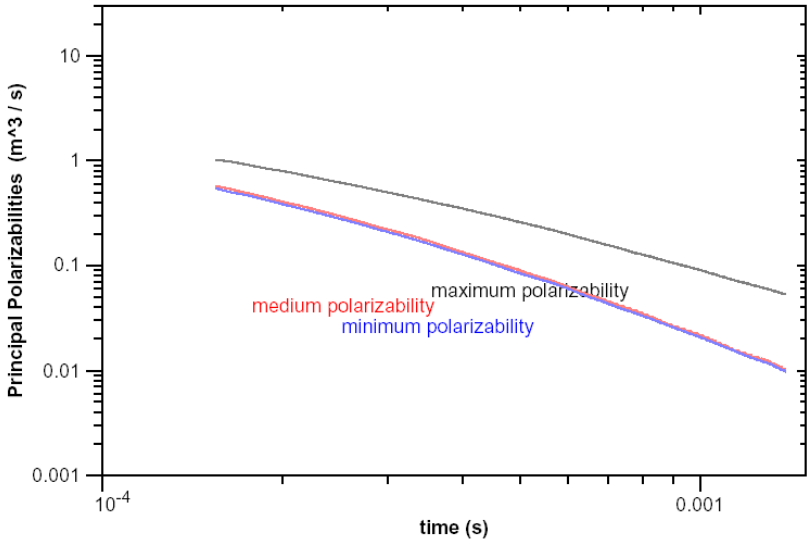
# Electromagnetic etector Systems (1)

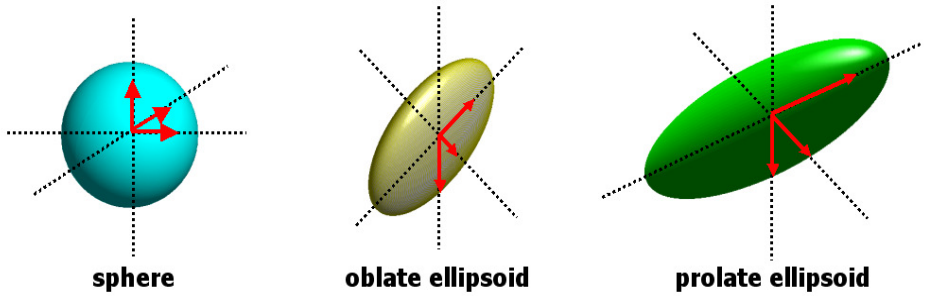


- Uses EM excitation and looks for induced currents
  - > 200dB dynamic range
- Applied to the UXO cleanup problem
- Developing version for IEDs to save lives
- R&D 100 Award Winner

Contact: Alex Ratti | ARatti@lbl.gov

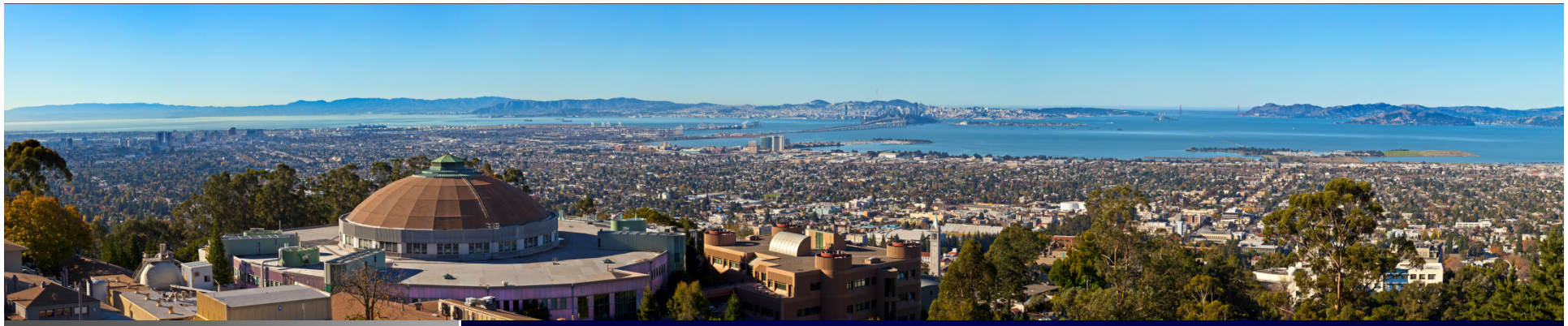
# Electromagnetic etector Systems (2)




R&D 100 AWARD WINNER

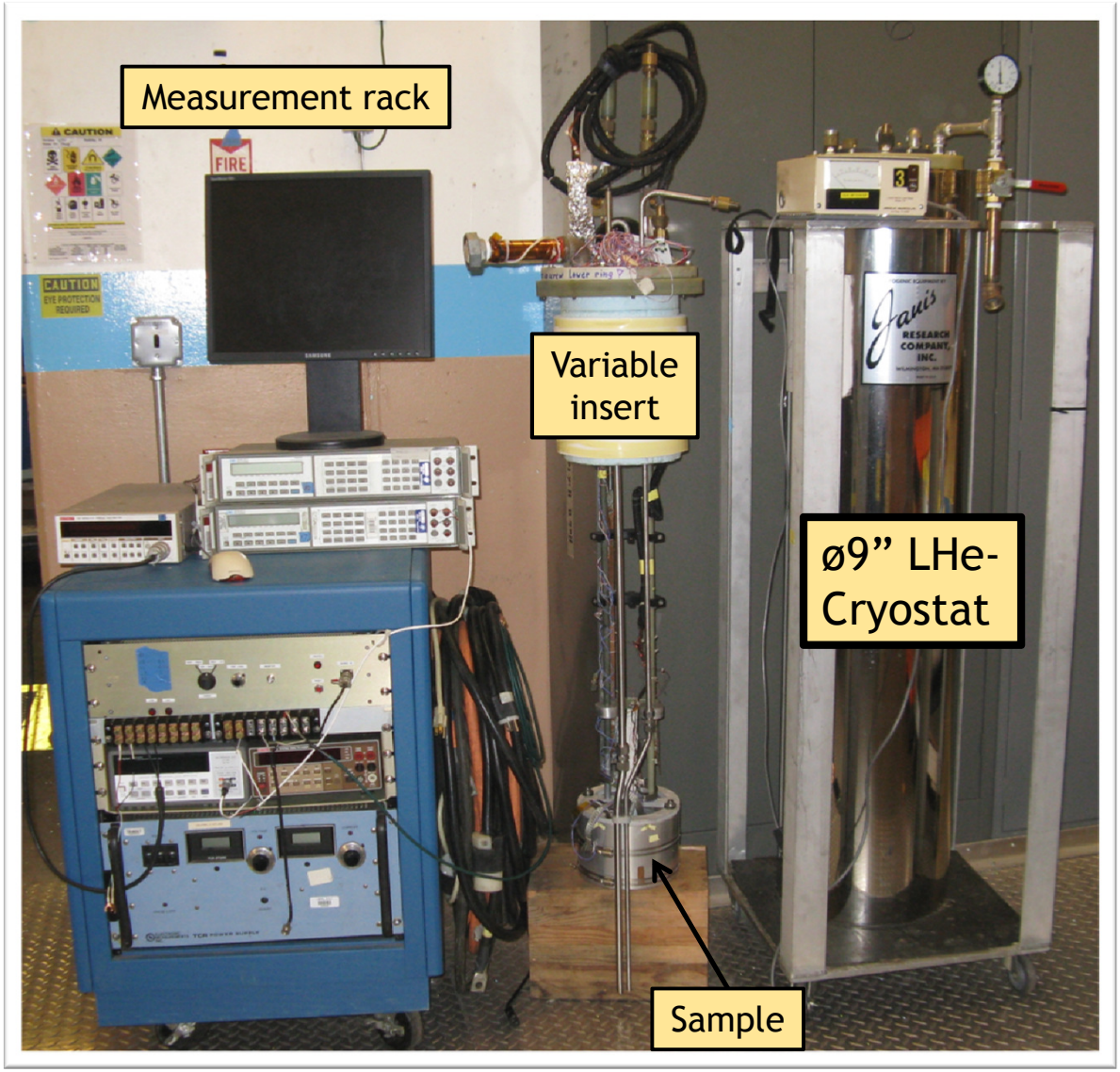
Contact: Alex Ratti| ARatti@lbl.gov



# Working with Engineering

## Mechanical Engineering Capabilities

# Cryogenics (1)



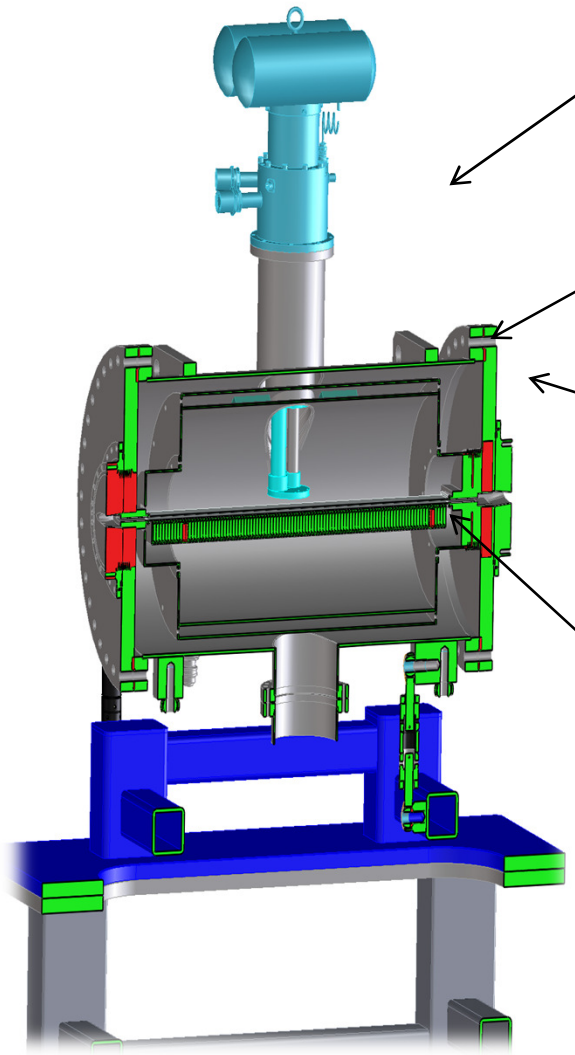

- Cryogenic design and measurement capabilities

- at cryogenic temperatures:
- liquid helium T=4.2 K
- liquid nitrogen T=78 K

9” Liquid helium cryostat and measurement system, featuring:
- Stabilized current source
- Nanovoltmeter
- Hall probe

Contact: Shlomo Caspi | S_Caspi@lbl.gov

# Cryogenics (2)




- ΔU/I characteristic => RRR determination
- Measurement of critical
  - superconductor parameters
- Cryogen-free cryostat allows sample temperatures in a wide range from 200 K down to 3.5 K
- Commercial two stage Pulse Tube Refrigerator
- Typ. Cooling performance:
  - 1.2 W @ 4.2 K & 30 W @ 50 K

Contact: Shlomo Caspi| S_Caspi@lbl.gov

# Design, Fabrication & Installation of Large Physics Detectors (1)

Electromagnetic tower construction and assembly

Design and fabrication of readout electronics


Super module assembly and calibration

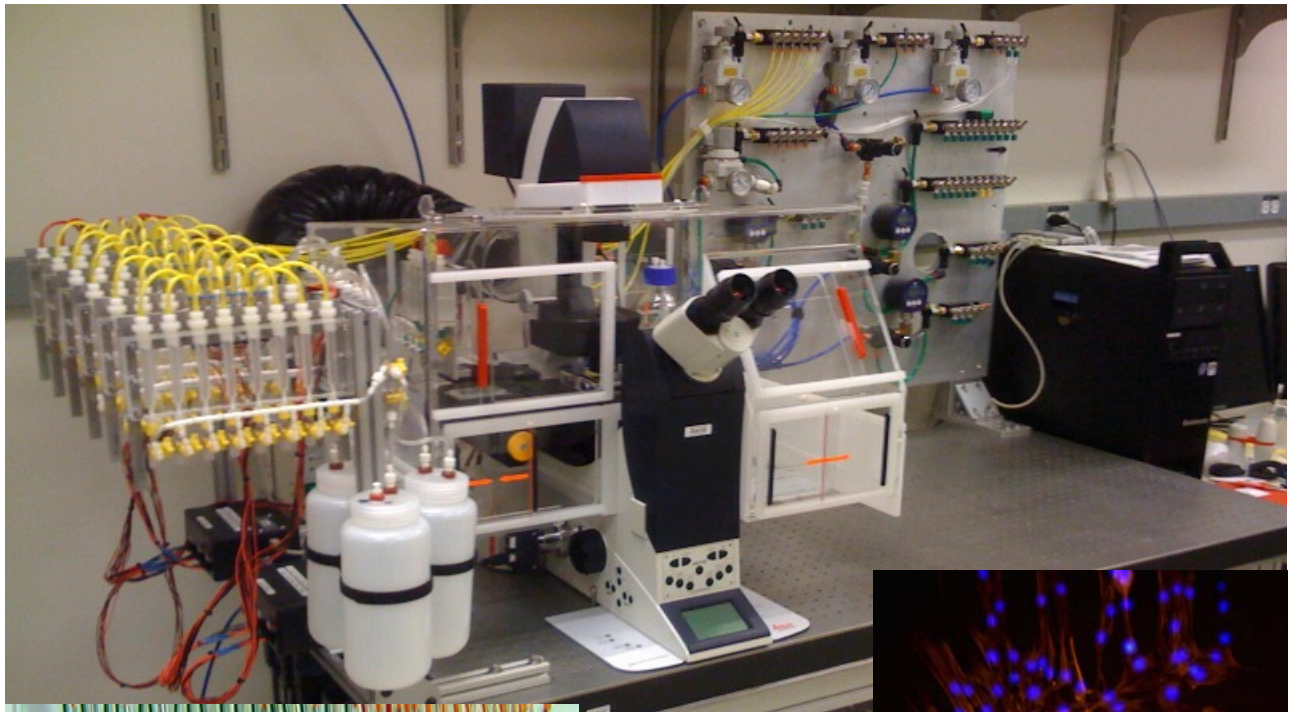
Contact: Joseph Rasson | JERasson@lbl.gov

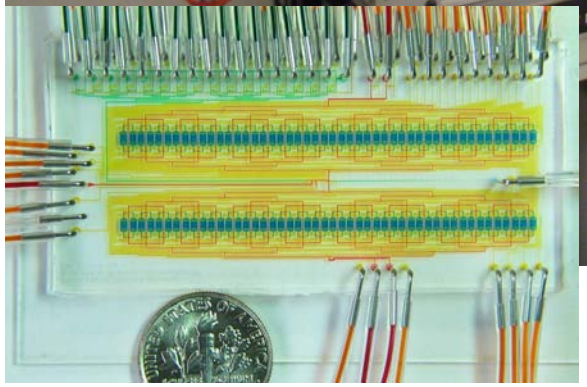
# Design, Fabrication & Installation of Large Physics Detectors (2)

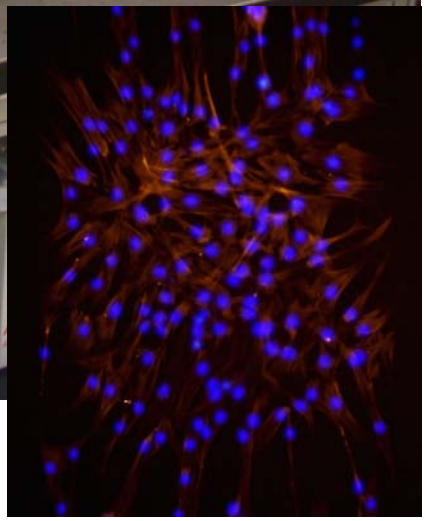
- Physics detectors are developed to understand the evolution and structure of nuclear matter from the smallest building blocks, quarks and gluons, to the elements in the universe created by stars.
- The ALICE Detector at CERN will open a new high-energy frontier in the physics of ultra high-density hadronic matter and the Quark Gluon Plasma (QGP).
- LBNL designed the Electromagnetic Calorimeter for the ALICE.
- Fabricated18 super modules, each weighs about 8 tons. 10 Super modules are already installed and participating in the physics runs

Contact: Joseph Rasson | JERasson@lbl.gov

# icrofluidics Laboratory (1)



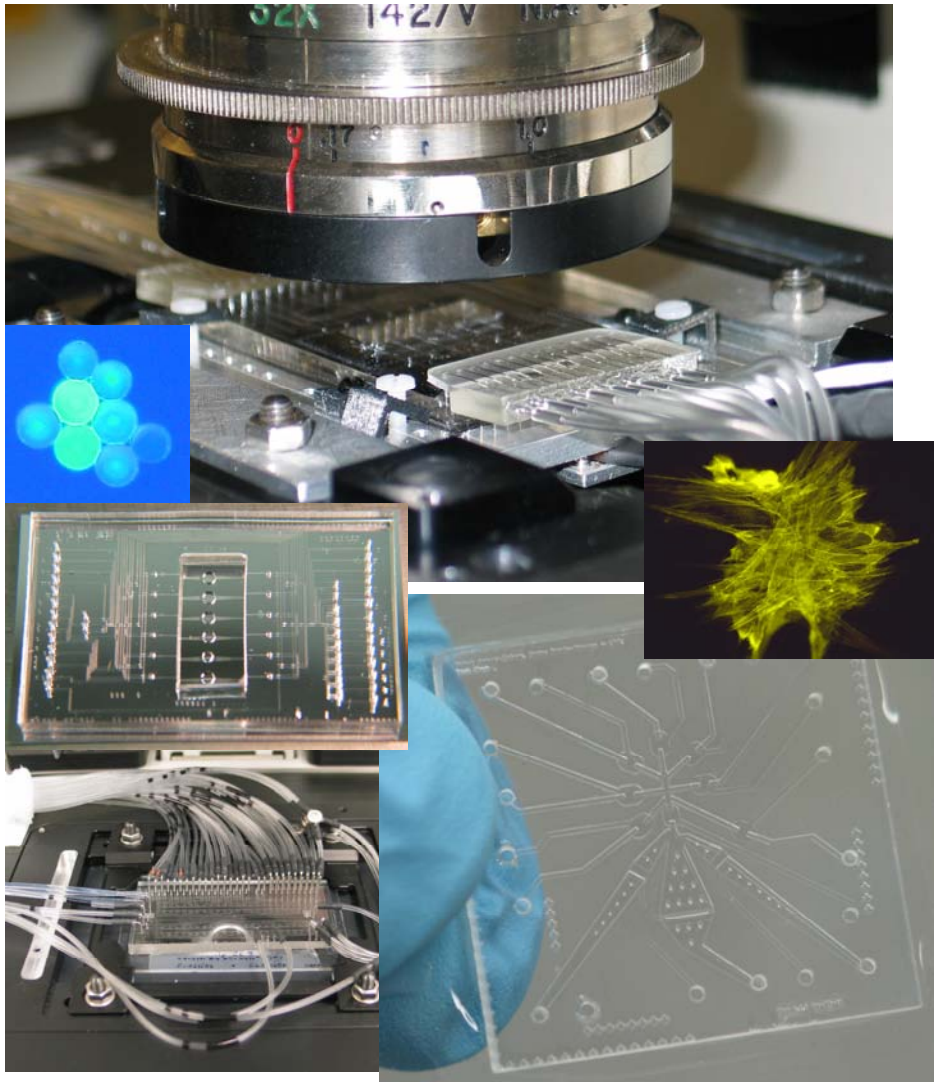




Fully automated, microfluidics-based cell culture system developed

Contact: Rafael Gomez-Sjoberg| Rgomez@lbl.gov

# icrofluidics Laboratory (2)

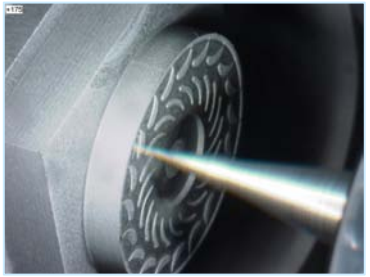


- State-of-the art capabilities
- Microfabrication by multi-layer soft lithography (PDMS), and other techniques
- Microfluidic systems for biology, biochemistry, and chemistry
- Expertise on automation and instrumentation (hardware + software)
- Extensive experience with microfluidics-based mammalian cell culture

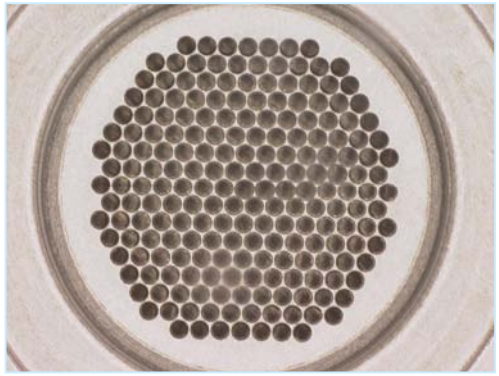
Contact: Rafael Gomez-Sjoberg| Rgomez@lbl.gov

# icro achining

Motor stator with .007 diameter radius slots
Material-Steel (penny in the front)



Machining with .0004 end mill
Material-Carbon



1mm hole array with .25mm
wall thickness in aluminum

Machined frame
Material-Stainless
Steel Comparison-
sitting on a dime

Micro-machining requires a machine tool that has very high sensitivity and fine resolution in the feed axis. Machines must also have very precise spindles capable of high-speed rotation with low dynamic run out, under .003mm.

Contact: Guy Pulsifer| GRPulsifer@lbl.gov

# icro Finishes

Bottom and Top electrodes for 88 in. Cyclotron Axial Injector (size approx 2” dia.)

Micro-machining does not necessarily equate to miniature parts. Many relatively large work pieces require ultra small features that can only be accomplished by micro-machining techniques.

Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# Stereo Lithography

Atlas wire ribbon guides

Ergonomic finger rest for JGI

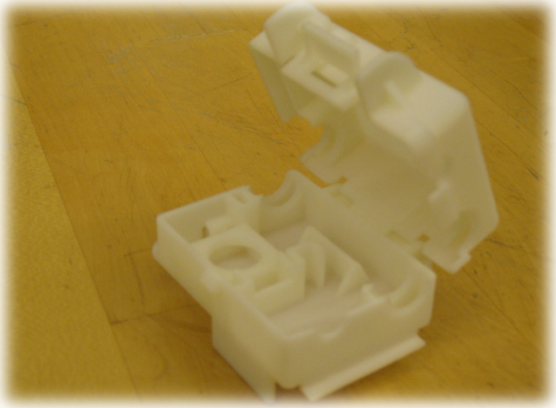
Burner for
Environmental Energy

**Stereo lithography**

machines utilize a vat of liquid photopolymer resin and a UV laser to build parts one layer at a time. On each layer a laser beam traces a part cross-section pattern on the surface of the liquid resin. Exposure to the UV laser light cures the pattern traced on the resin and adheres it to the layer below.

Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# 3 Printing-Rapid Prototype



Battery Box

Free form structure

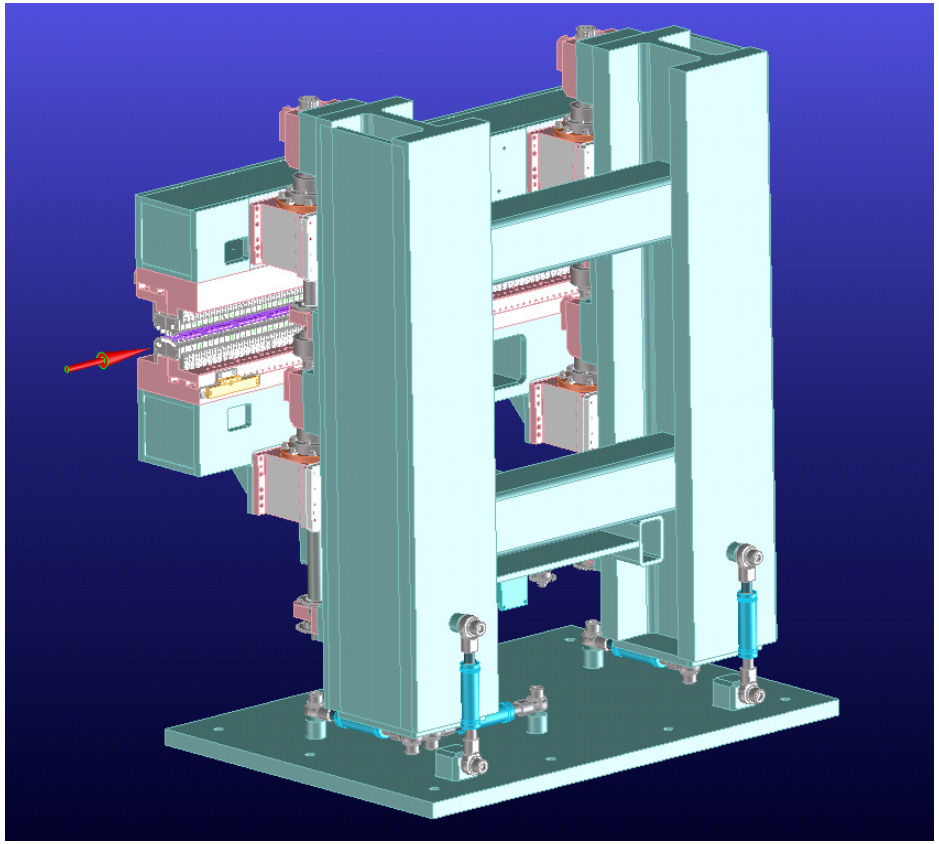
Assortment of working parts

Rapid prototyping machines create intricate 3D mockups and sometimes fully functional components and assemblies.

The 3D printer models from the bottom up with precisely deposited layers of modeling and support material, then a water-based solution removes the support material to complete your detailed design. The models can then be drilled, tapped, sanded and painted.

Contact: Guy Pulsifer| GRPulsifer@lbl.gov

# Permanent/Hybrid agnets

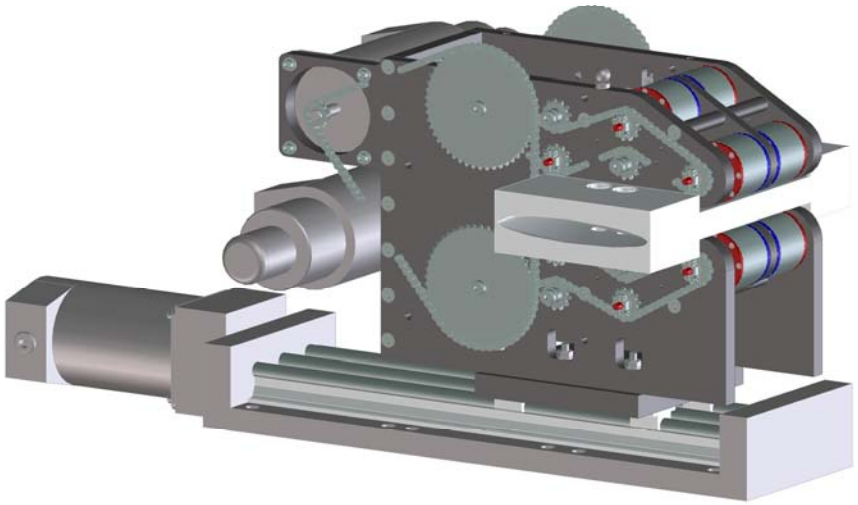


- Pure permanent magnet (NdFeB) and hybrid magnet (PM+iron) design and fabrication

ALS Merlin Elliptically Polarizing Undulator – high res. inelastic scattering & ARPES studies of electronic structure in strongly correlated systems

Contact: Steve Marks| S_Marks@lbl.gov

# Permanent/Hybrid agnets

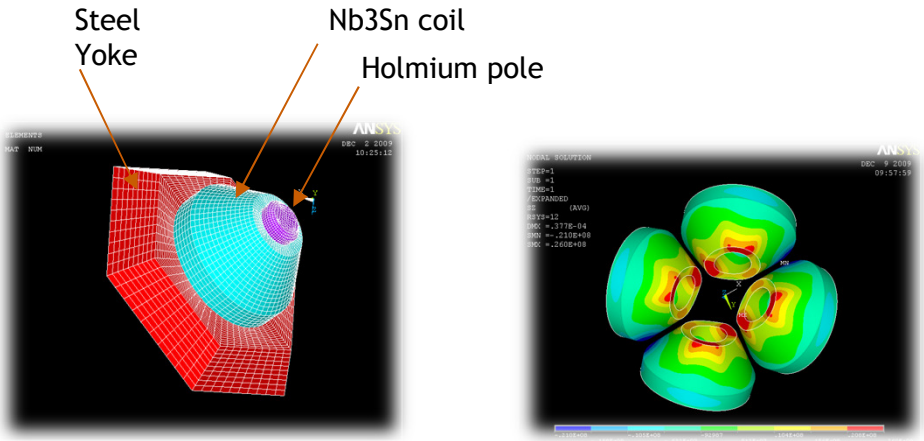


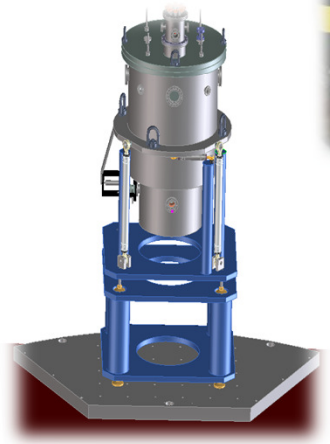
ALS chicane pure permanent magnet iron-free, hysteresis-free adjustable field dipole

- Detector magnet, accelerator magnet, and small magnetic device applications
- Optimal for designs with compact length scales (<~10cm) and high fields (B>1T)
- Hysteresis-free, variable field strength, and field shaping capabilities

Contact: Steve Marks| S_Marks@lbl.gov

# Superconducting agnets (1)




- Analysis:
  - 3D magnet and thermal analysis (e.g. Eddy currents, quench propagation, etc.)
  - 3D structural analysis (anisotropic materials, temperature dependence, etc.)
- Component testing:
  - Short samples, coils
  - Anisotropic elastic properties
- Project examples:
  - ALS Superbends
  - Superconducting Vector Magnet
  - Superconducting undulator development

Contact: Shlomo Caspi| S_Caspi@lbl.gov

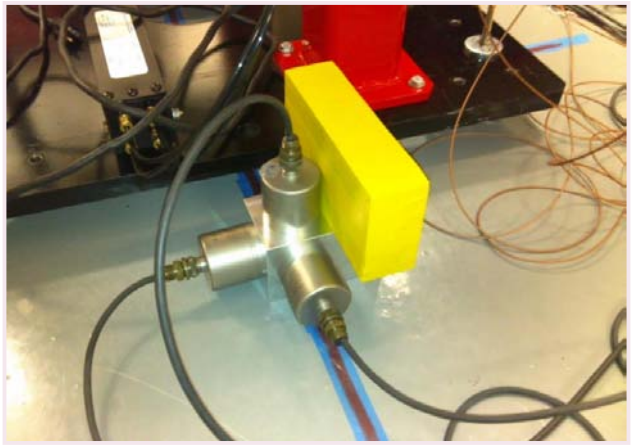
# Superconducting agnets (2)

- Complete superconducting magnet project capabilities:
  - Consultation with clients on magnet needs, constraints
  - Aid/partner w/ proposals, budget & schedule estimates
  - State-of-the-art analysis and modeling capabilities
  - Expertise in magnet design: magnetic, mechanical, protection
    - Coil winding, heat treatment, epoxy-impregnation
  - Significant experience in magnet and cryostat fabrication
    - Materials: Low and High temperature superconductors
    - Cryostats: Cryogen-based and Cryocooler-based
  - Associated component testing:
    - Experience and capabilities: Jc measurements, cold-mass qualification, anisotropic material property determination

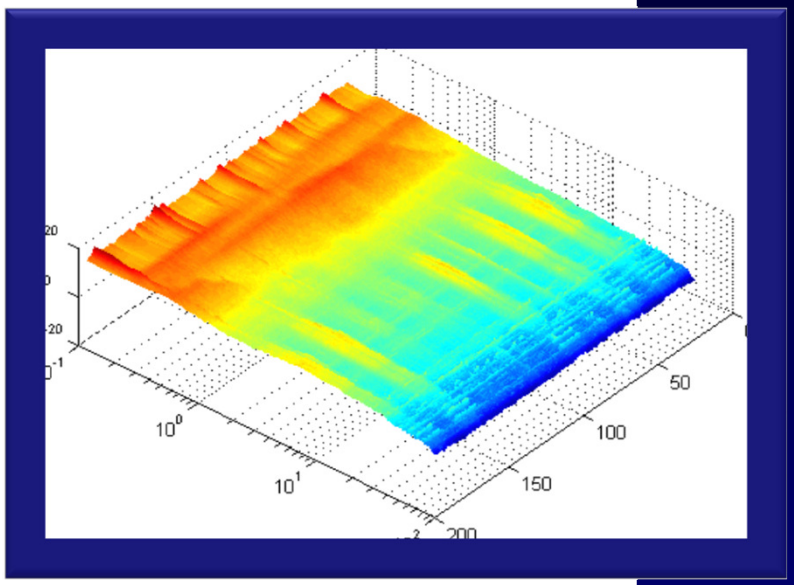
Contact: Shlomo Caspi| S_Caspi@lbl.gov

# ibration Analysis Control (1)

- Onsite vibration analysis and monitoring using seismometers, accelerometers, or interferometers.



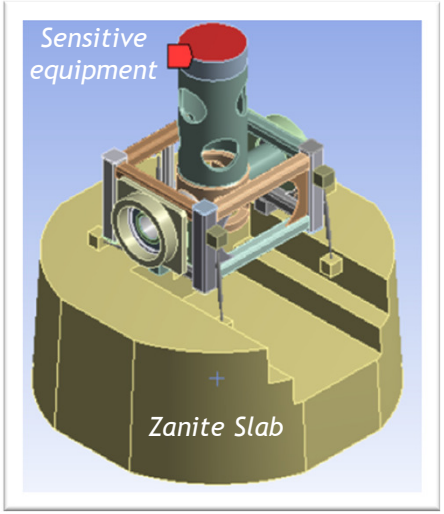
High sensitivity accelerometers



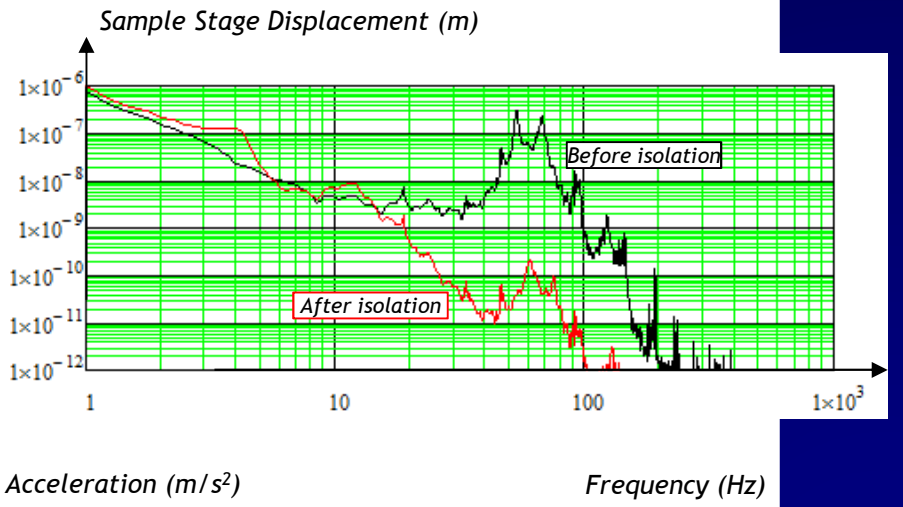

Contact: Ross Schuleter| RDSchlueter@lbl.gov

# ibration Analysis Control (2)

- Development of vibration Damping/Isolation strategies
- Prediction of the vibration behavior for future installations
- Troubleshooting of existing installations

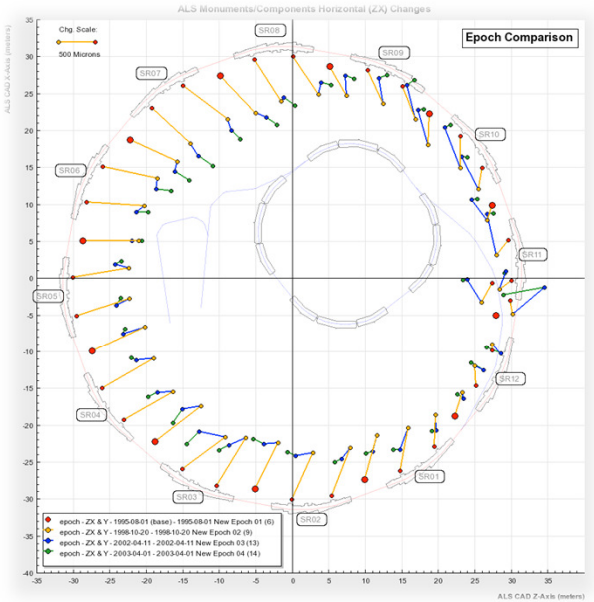




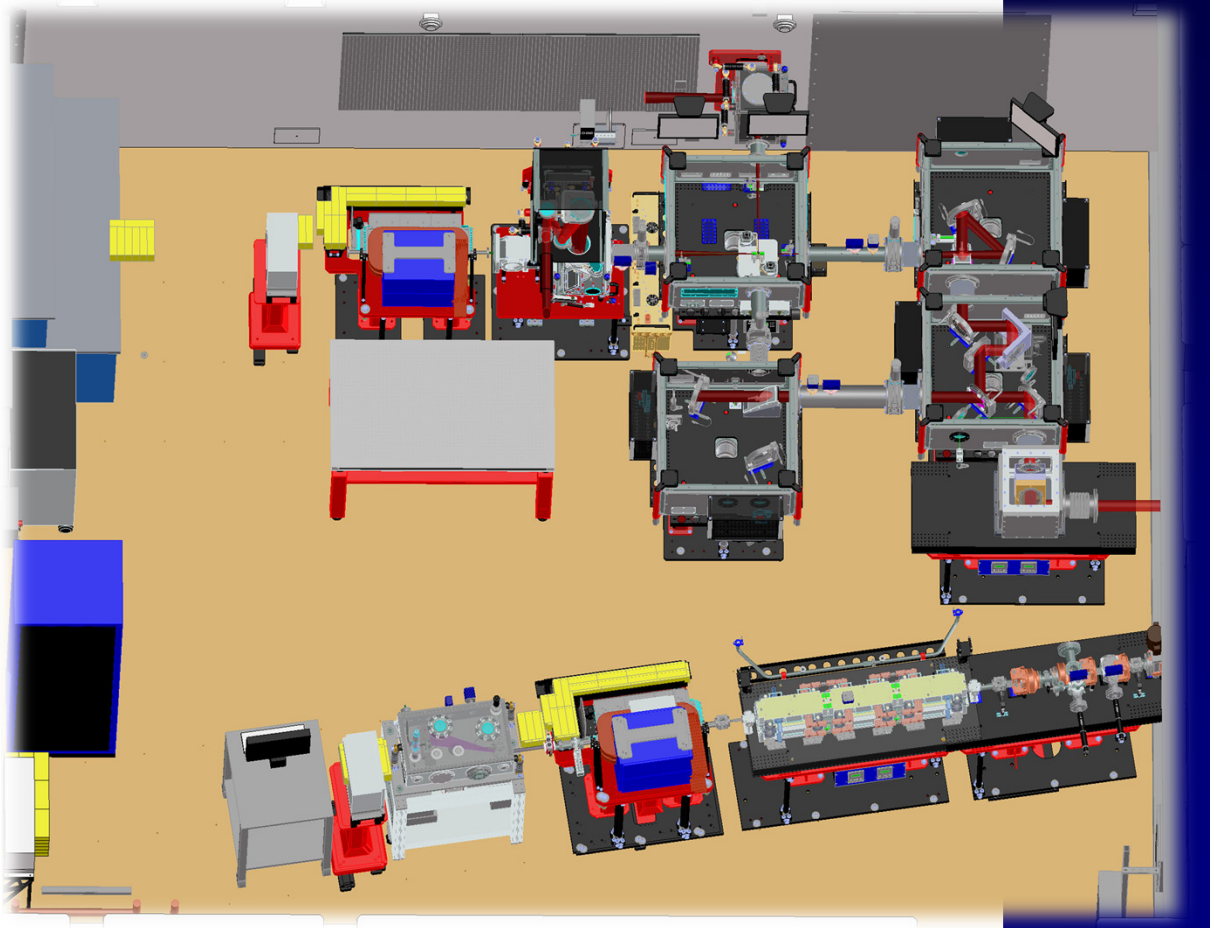



Contact: Ross Schuleter| RDSchlueter@lbl.gov

# Survey and Alignment (1)




- ALS Storage ring corrections (left)
- Alignment of Laser plasma system LOASIS (bottom)



Contact: Ross Schuleter| RDSchlueter@lbl.gov

# Survey and Alignment (2)


- Broad Capability for Particle Accelerators, Experimental Systems, Components and Infrastructure

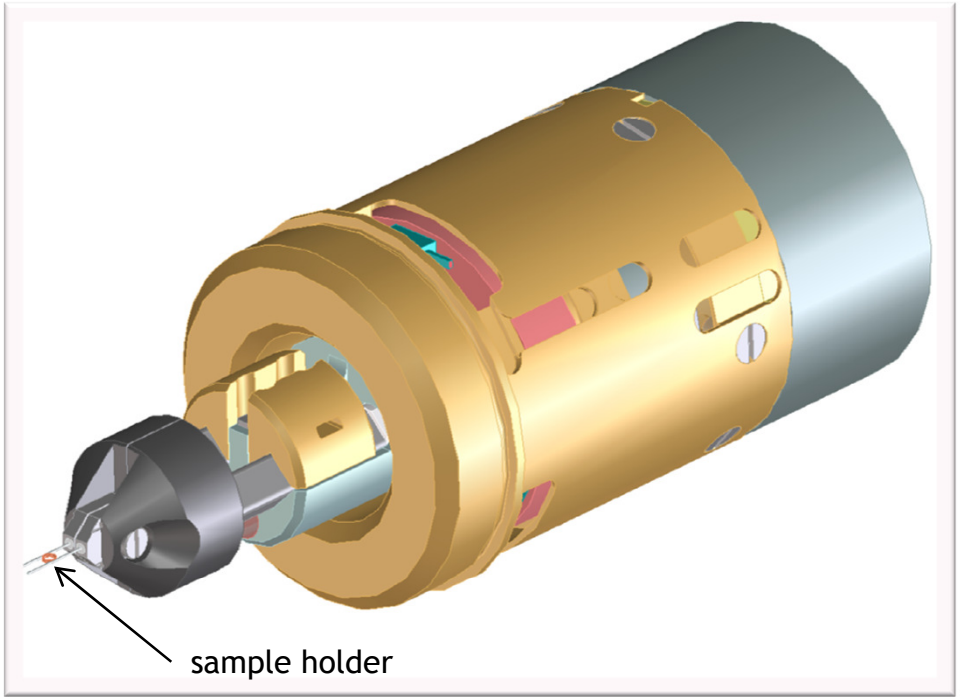
Contact: Ross Schuleter| RDSchlueter@lbl.gov

# Survey and Alignment (3)

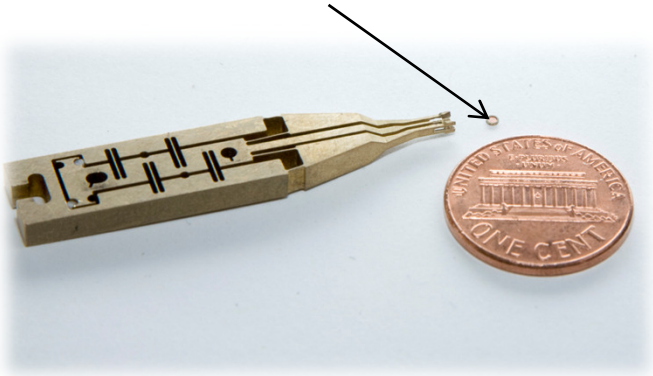
- Large scale particle accelerator laser tracker survey & alignment to <50 micron rms accuracy over 80 meters distance
- Small/medium scale CMM arm survey and fidicialization <30 micron rms accuracy
- Medium and large scale facilities and infrastructure survey capability
- Support for all accelerator projects on site
- Successful re-alignment of entire ALS in 2011

Contact: Ross Schuleter| RDSchlueter@lbl.gov

# Precision echanisms (1)




- TEAM Electron Microscope Stage capable of movement precision of 0.014 nm and near-360-degree positioning along two orthogonal axes

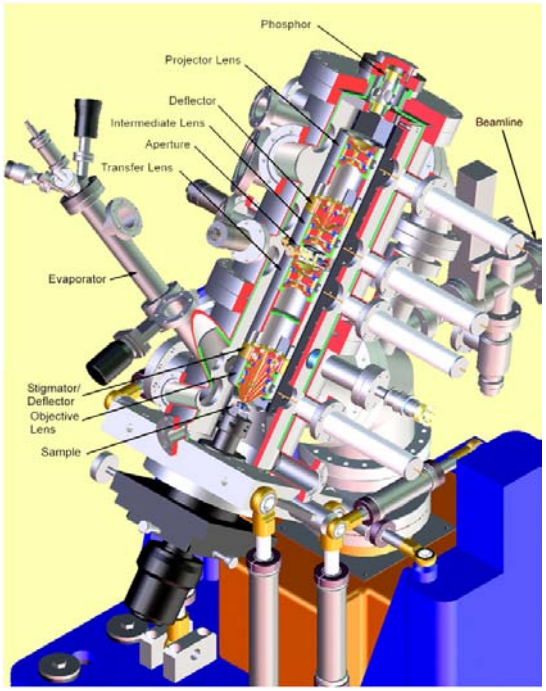


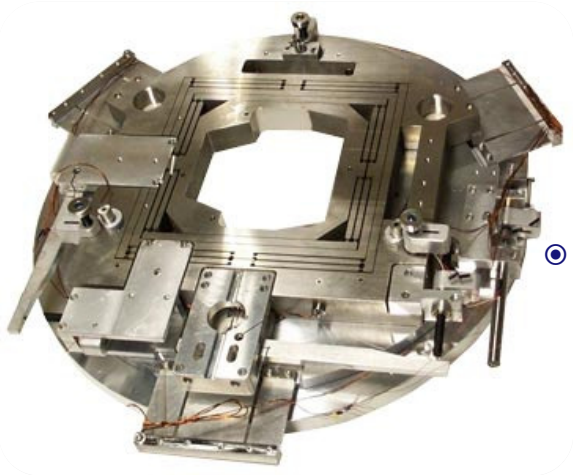

- TEAM Microscope tweezers and sample holder

R&D 100 AWARD WINNER

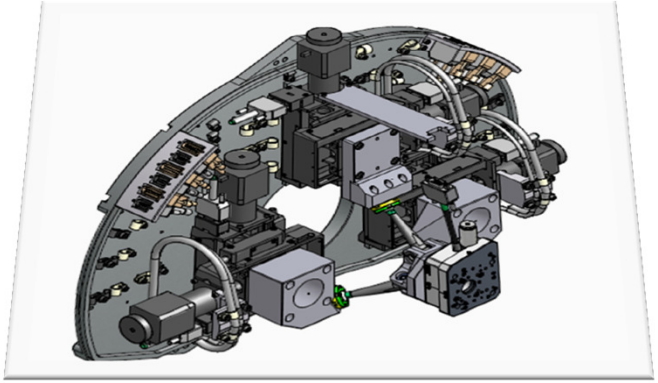
Contact: Ken Chow| KPChow@lbl.gov

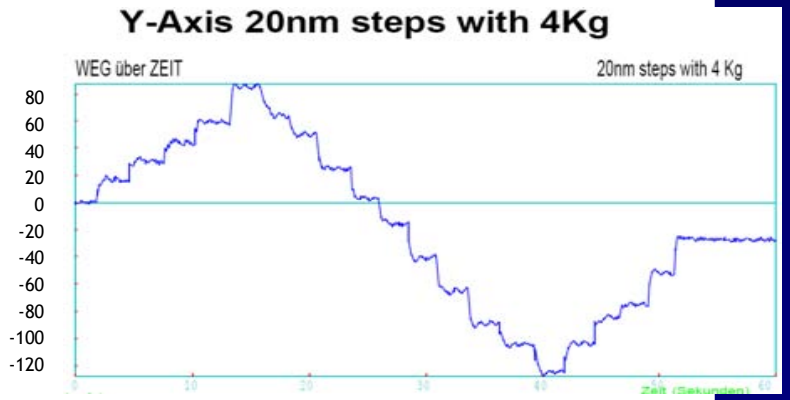
# Precision echanisms (2)



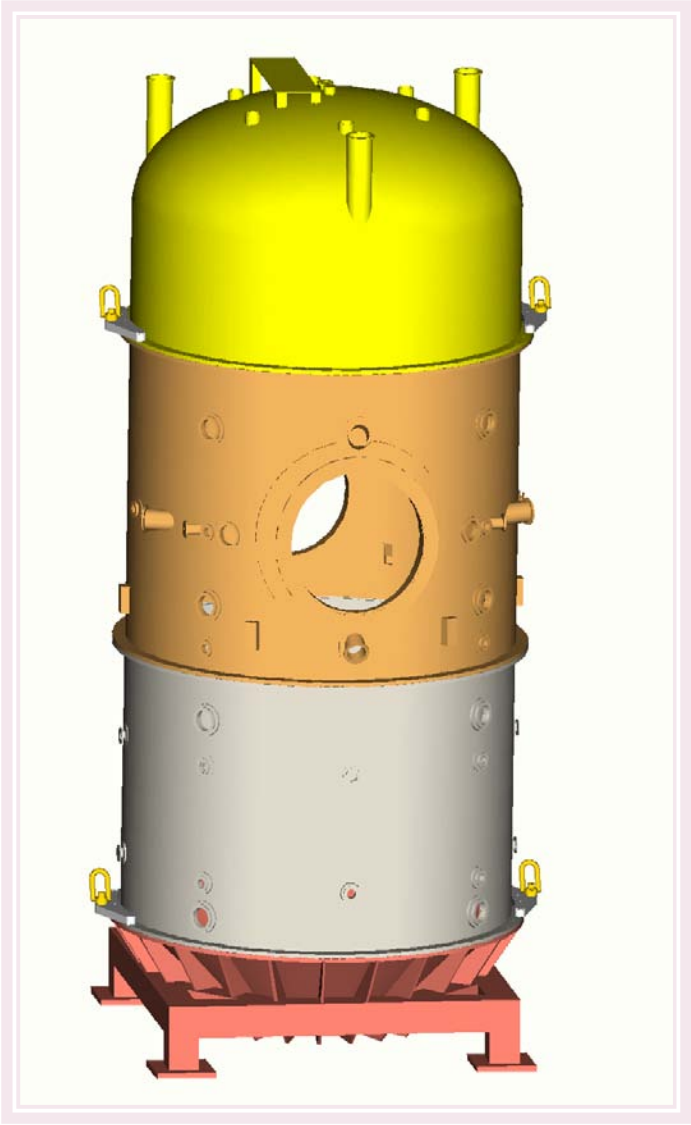
- Design and fabrication of custom nano-actuators, precision electro-mechanical assemblies, optical mounts and assemblies
- Installations in cryogenic, ultra high vacuum, and radioactive environments






Contact: Ken Chow| KPChow@lbl.gov

# acuum Components (1)

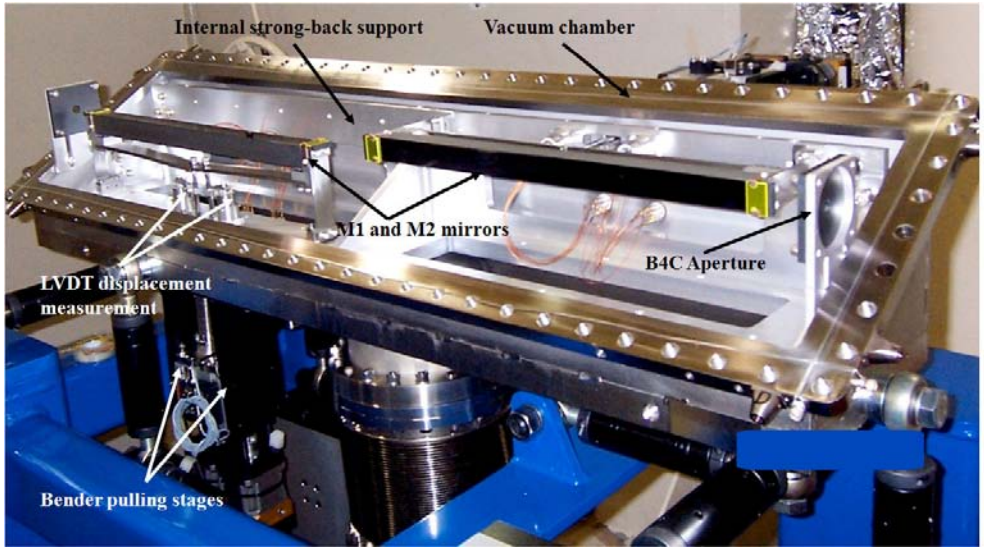


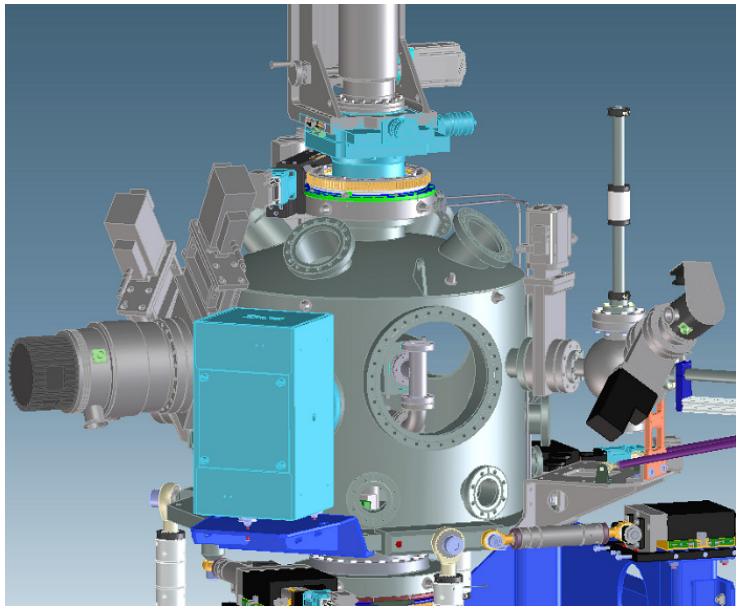
- 24-ton high vacuum vessel for a 3.2 MV electron injector

30 feet

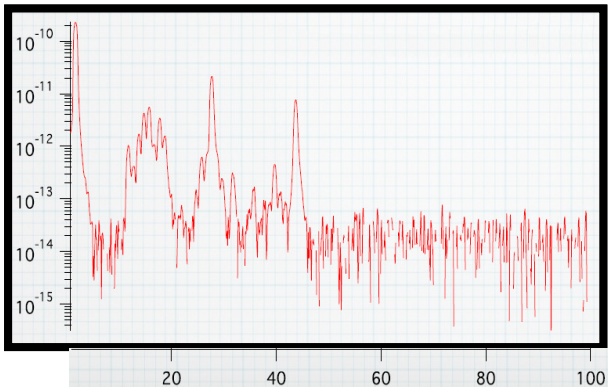
Contact: Ken Chow| KPChow@lbl.gov

# acuum Components (2)



- Design of vacuum chambers and components for operation to ultra-high and extreme high vacuum regimes (UHV and XHV)
- Specialized fabrication, handling, cleaning, and processing for UHV
- Residual Gas Analysis
- Materials and component testing for UHV compatibility and qualification



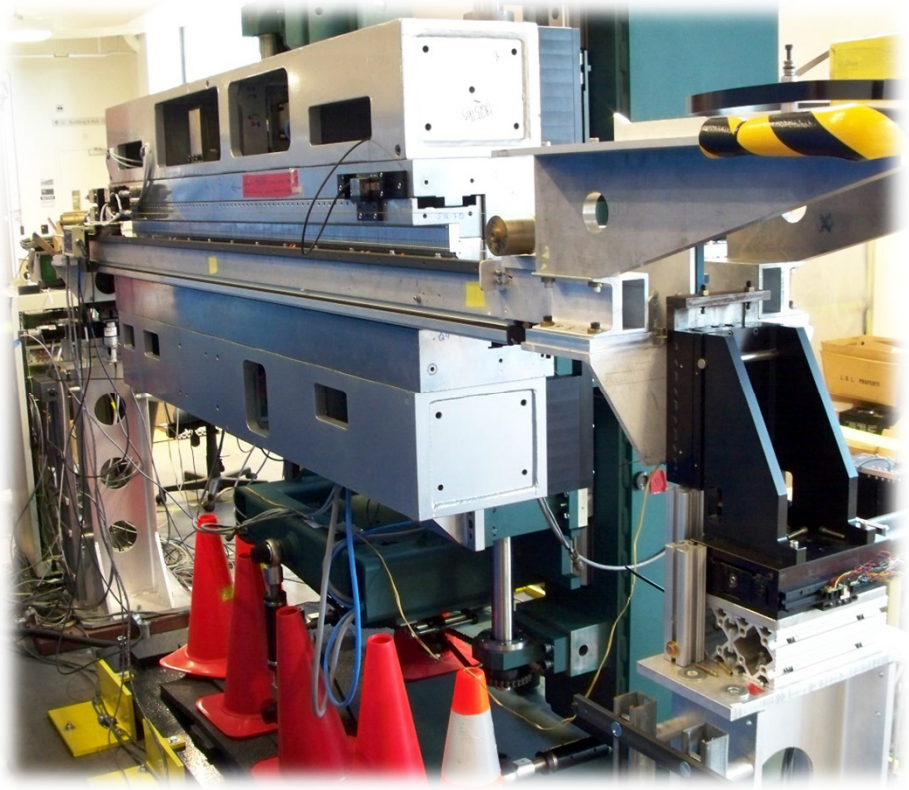

Contact: Ken Chow| KPChow@lbl.gov

# agnetic easurements Capabilities

- Undulator Test and Tuning
  - Hall probe scans
  - Integral scans
- Helmholtz Coil for magnetic block characterization
- Rotating Coil bench for multiple magnet measurement
- 3D Hall Probe field map
- Pulsed Wire for magnetic axis location
  - R&D for future capabilities

Contact: Steve Marks| S_Marks@lbl.gov

# Undulator Testing and Tuning

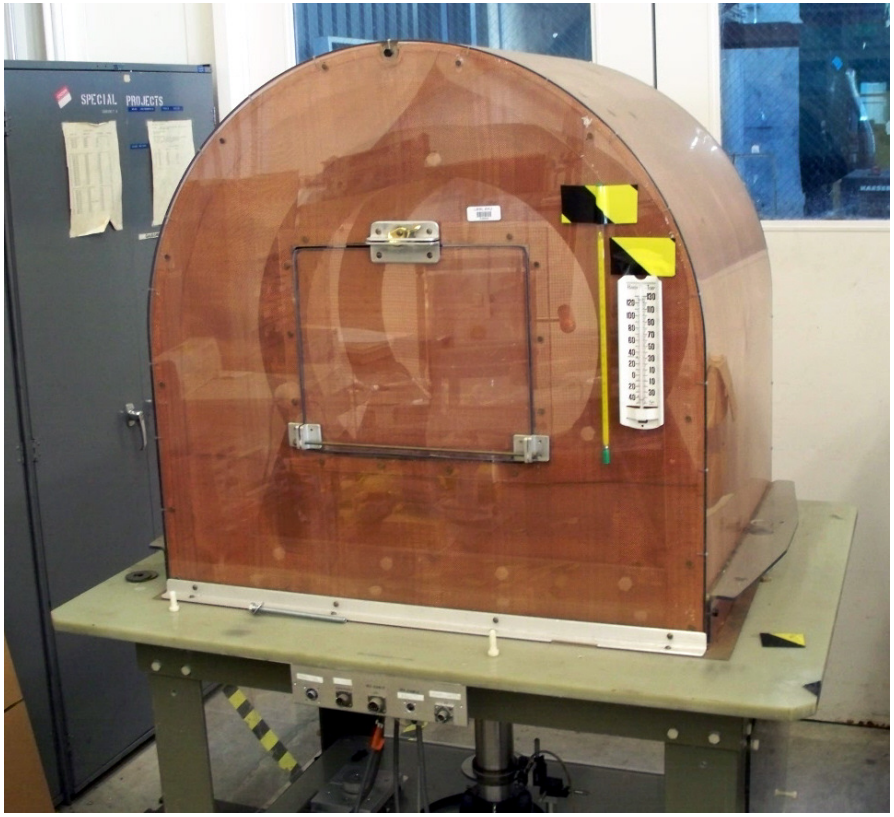


Elliptically polarizing undulator under test

- Detailed, high precision magnetic measurements
  - Hall probe scans to characterize and tune optical phase and electron trajectory
  - Integral scans to characterize affect on electron dynamics

Contact: Steve Marks| S_Marks@lbl.gov

# agnetic Block Characterization

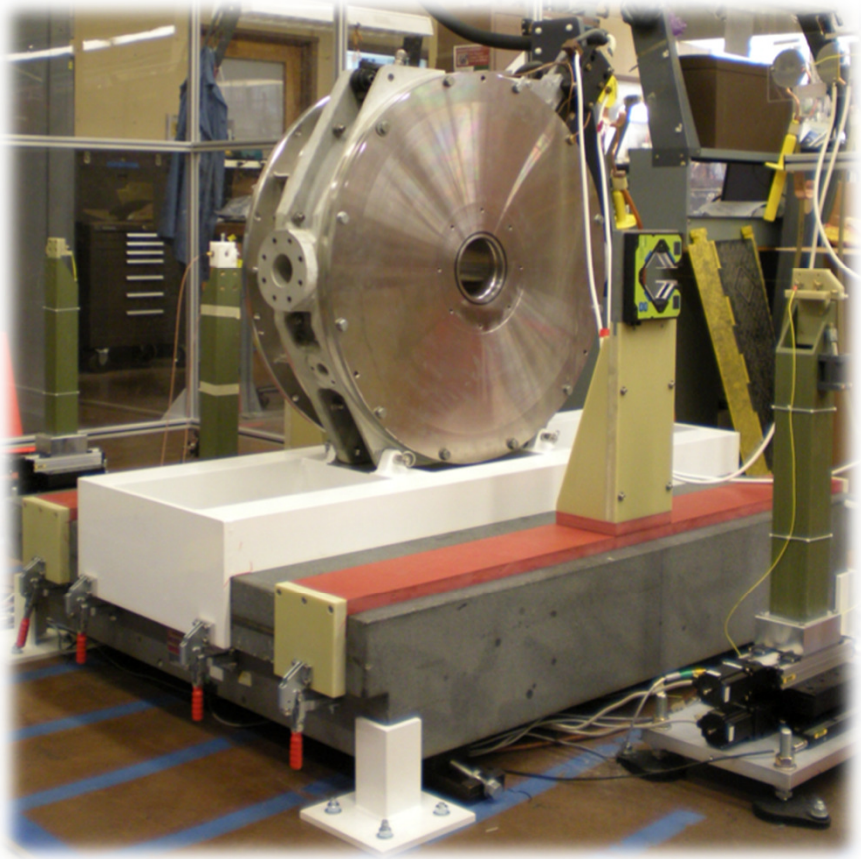



Helmholtz Coil with block rotation and flip, safety cover incorporating electrical shielding

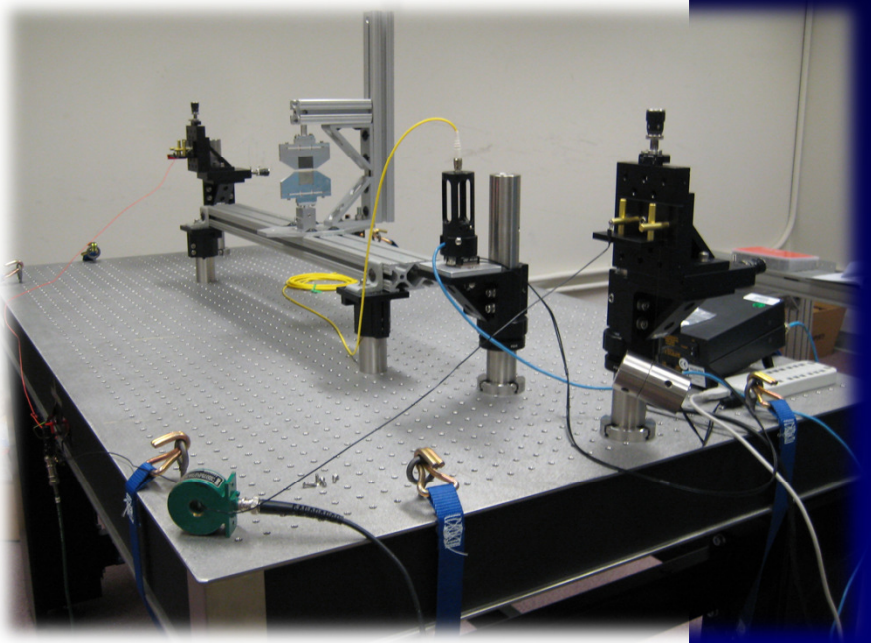
- Helmholtz coil to measure dipole moment
  - Used to characterize blocks for PM and Hybrid undulators
  - Measurements used for block sorting to optimize magnetic field

Contact: Steve Marks| S_Marks@lbl.gov

# Pulsed ire Techniques



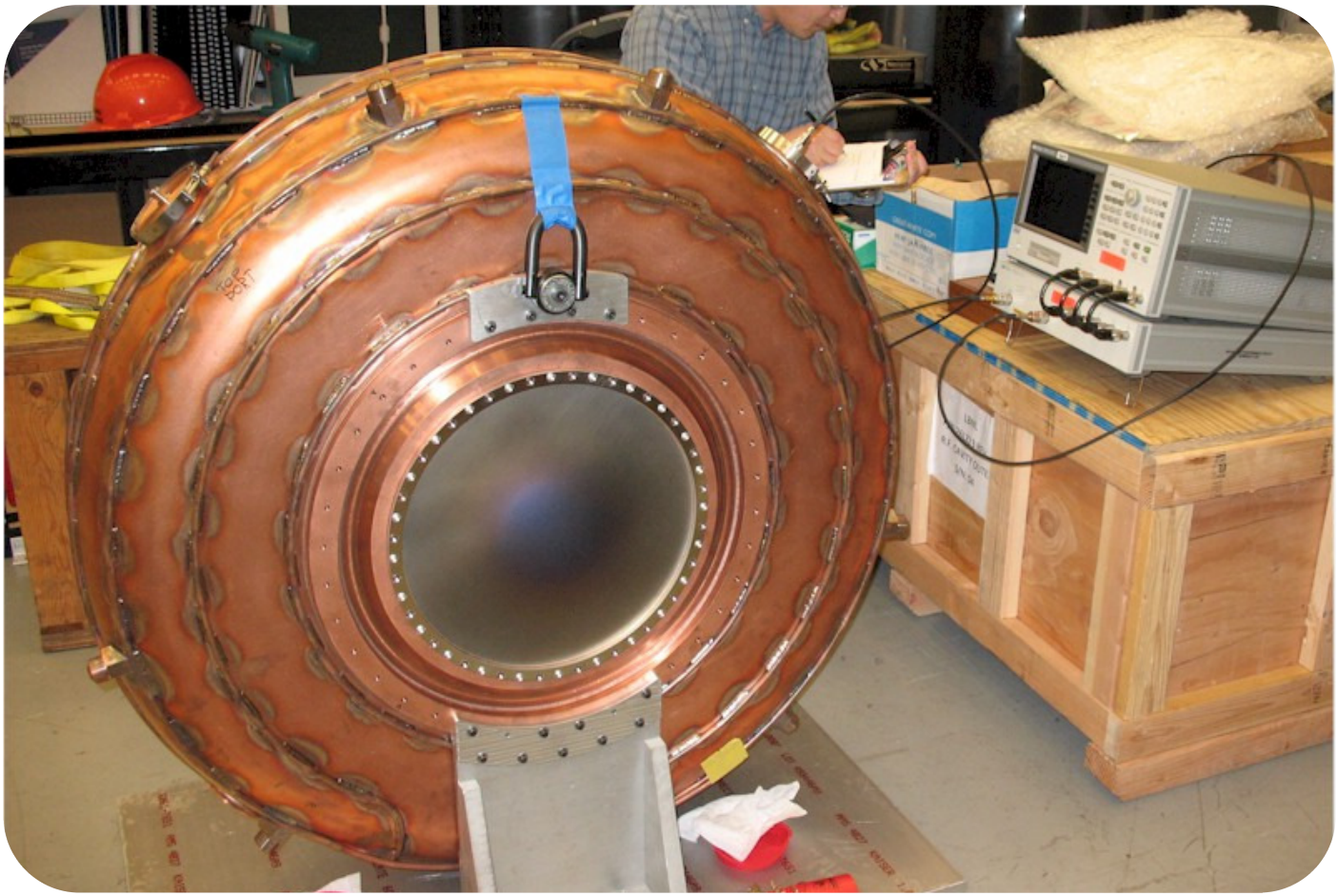
Pulsed wire system to locate central axis of NDCX-II pulsed solenoids



R&D: Pulsed wire system development for measurement of superconducting and small gap undulators

Contact: Steve Marks| S_Marks@lbl.gov

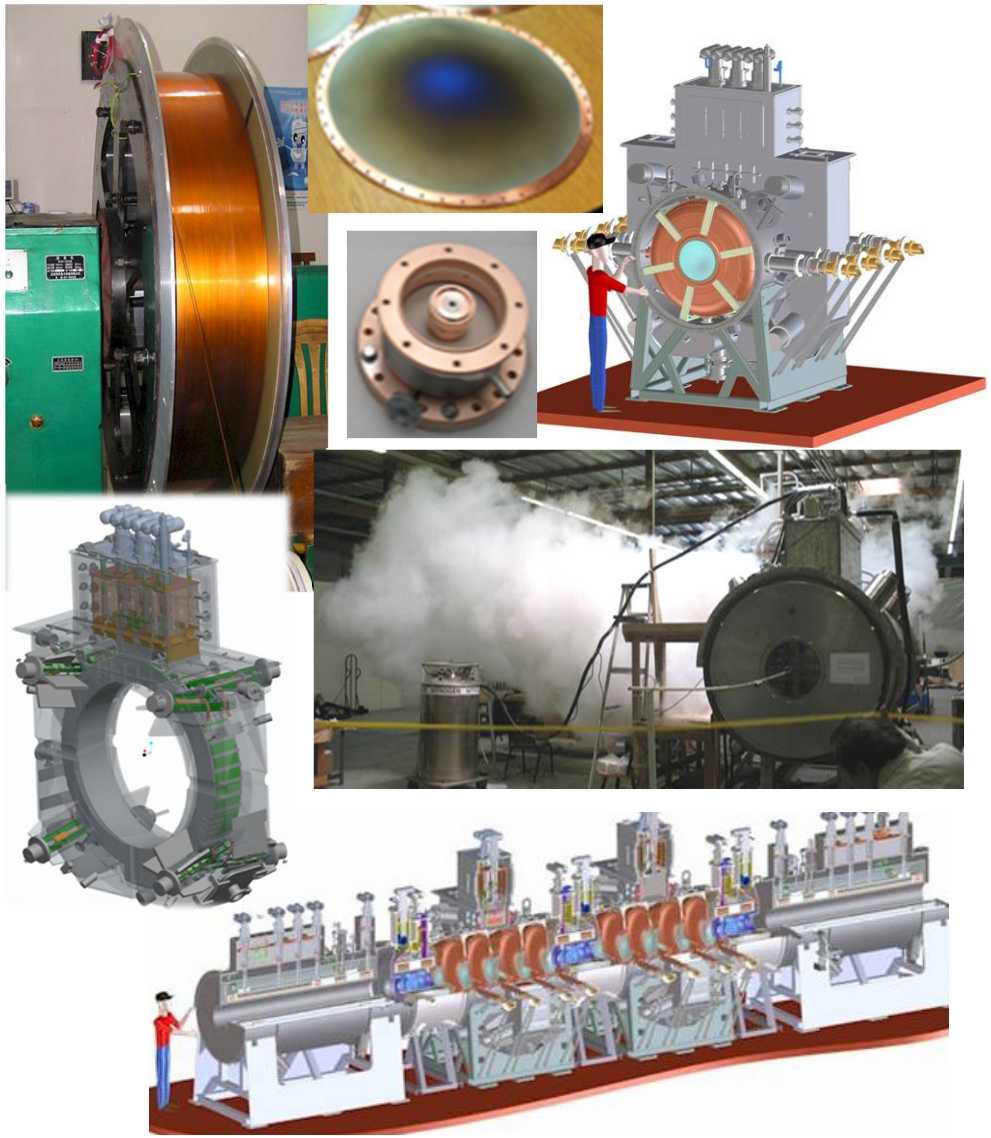
# uon Ionization Cooling Experiment (1)



- One of eight 201 MHz RF cavities designed by LBNL for the Muon Ionization Cooling Experiment (MICE) sited at Rutherford Lab in the UK

Contact: Steve Virostek| SPVirostek@lbl.gov

# uon Ionization Cooling Experiment (2)



- LBNL is a key member of the international MICE Collaboration
- Developed a specific RF cavity fabrication method for this application
- Utilized the specialized abilities of local vendors: E-beam welding, superconducting magnet construction, beryllium foil forming and brazing
- Key LBNL capabilities: design of RF cavities and superconducting magnets, RF, thermal and structural analysis

Contact: Steve Virostek| SPVirostek@lbl.gov

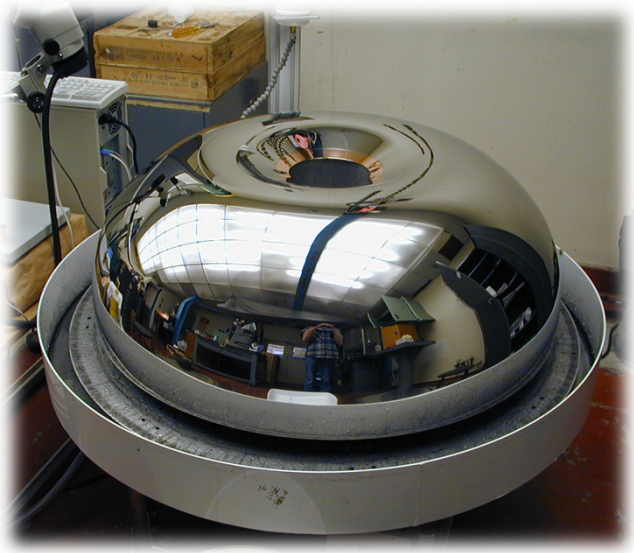
# ptics Shop (1)


Polished prism with hole.

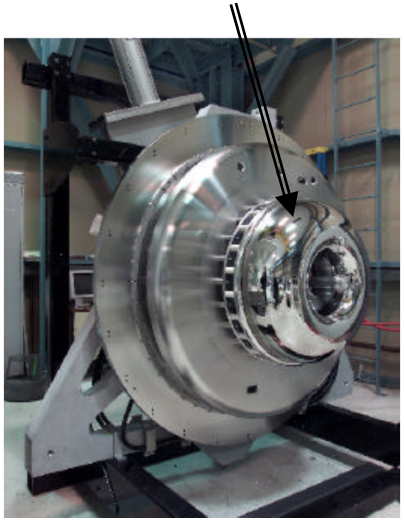
- The optics shop offers precision component fabrication to meet user specifications.
- Today simple lenses and mirrors are often purchased “outside”, its far more likely that the scientist will require custom geometries or modifications on a component.

Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# ptics Shop (2)



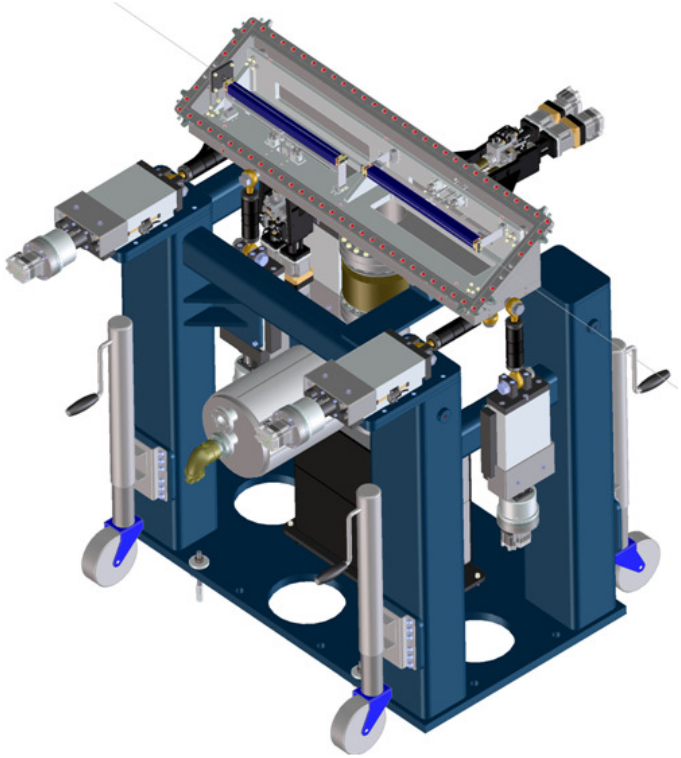
Polished DARHT anode component.

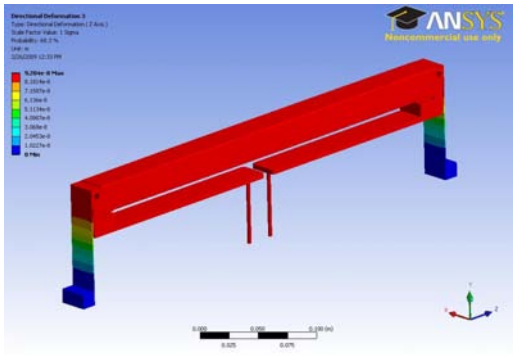


- The day to day operations involve more than just optics -
- Polishing large parts.
- Crystal substrate surface polishing.
- Precision sawing of ultra hard or brittle materials using diamond tooling.
- Knife-edge / Slit fabrication and lapping.
- Exotic materials- MgO, Ge, Si, $SrTiO_3$ , Piezo crystals, etc.
- Polish metal alloys to micro-inch finish.
- Bore holes 1mm and larger through glassy materials.
- Optical test surfaces for flatness to 1/10 wave visible light.

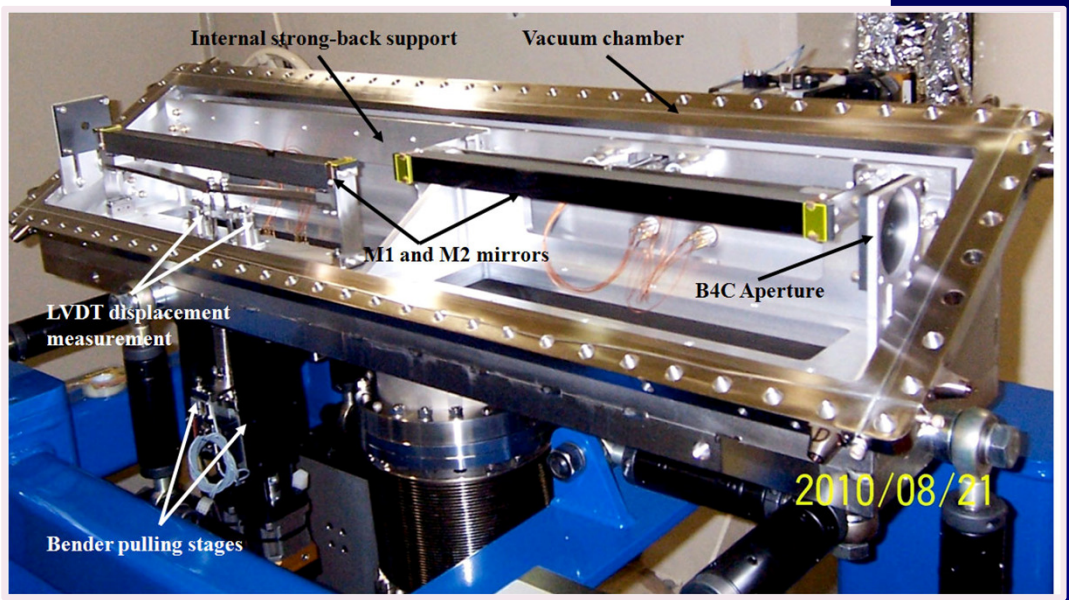
Contact: Guy Pulsifer| GRPulsifer@lbl.gov

# Precision Elliptically bent X-Ray ptics






- Kirkpatrick-Baez Mirror pair
  - (Built for the LCLS AMO Beamline)
  - Slope Errors < .2 microradians
  - Ultra High Vacuum




Contact: Ken Chow| KPChow@lbl.gov

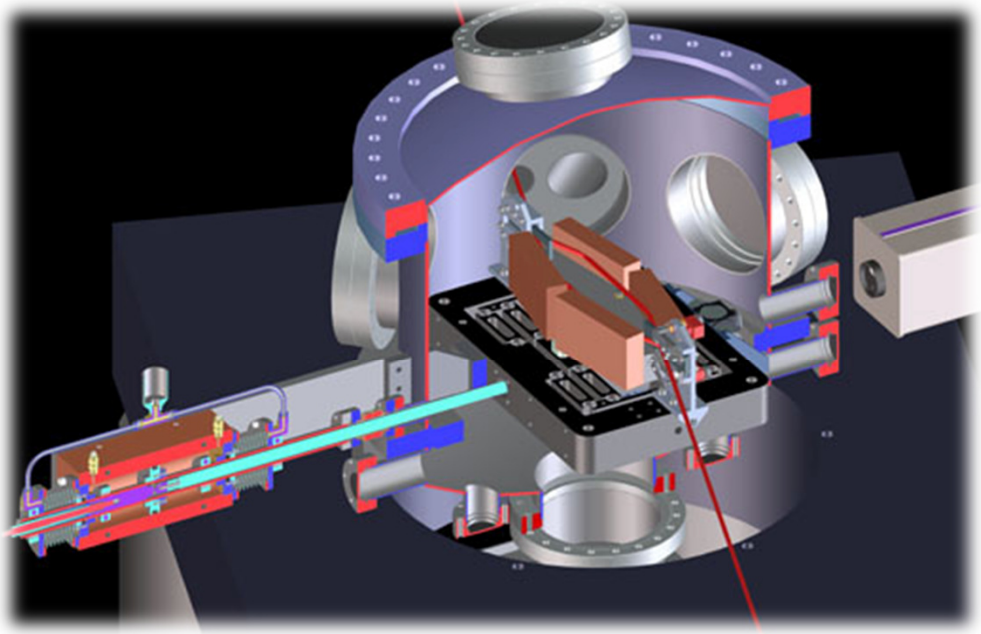
# Small Project Support

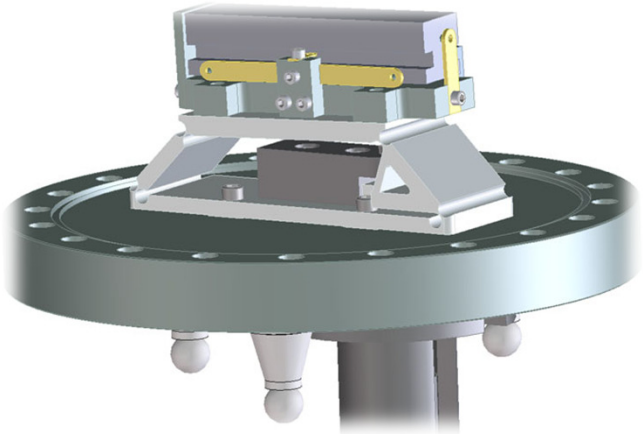

## A portable cryo-plunger

### for on-site intact cryogenic microscopy sample preparation in natural environments

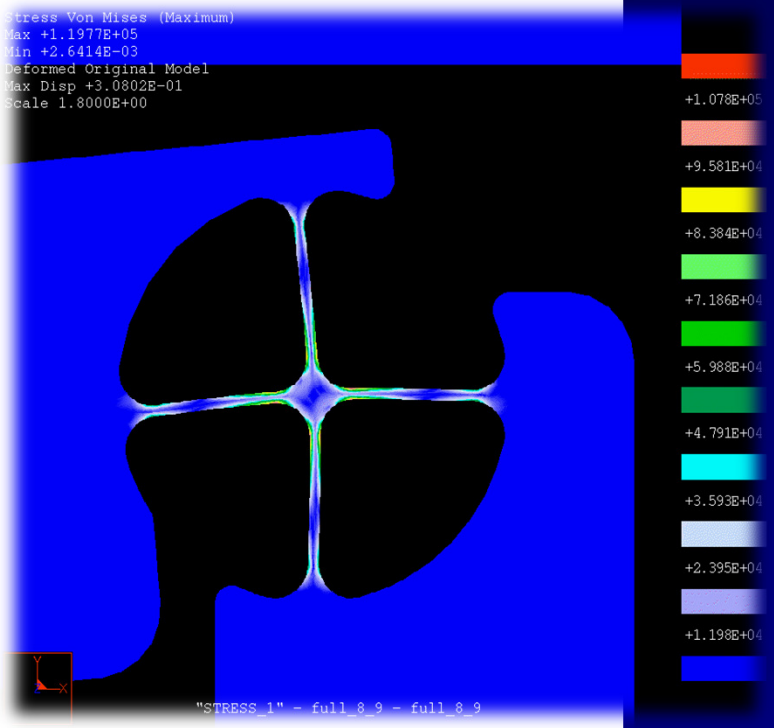
Contact: Rob Duarte | RMDuarte@lbl.gov

# Precision Flexures (1)



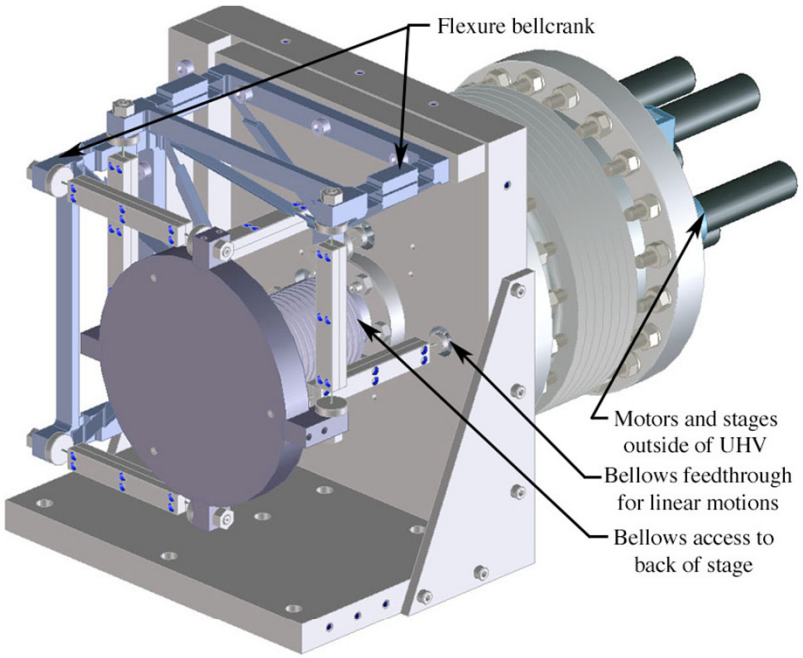


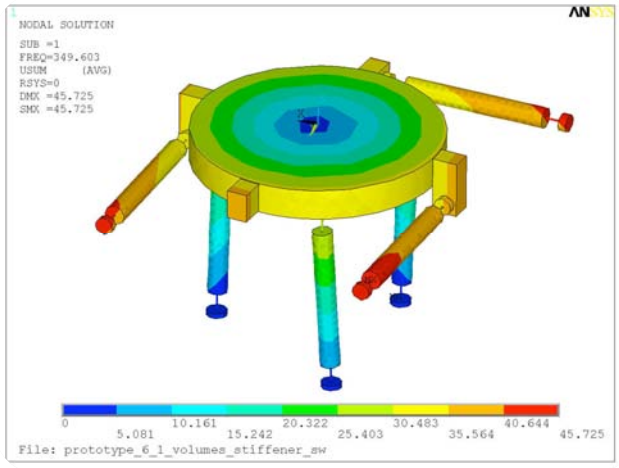
- Soft X-Ray Interferometer (left)
- Example of Interferometer flexure stress analysis (Bottom Right)
- Virtual center mirror steering flexure ( Bottom left)




Contact: Ken Chow| KPChow@lbl.gov

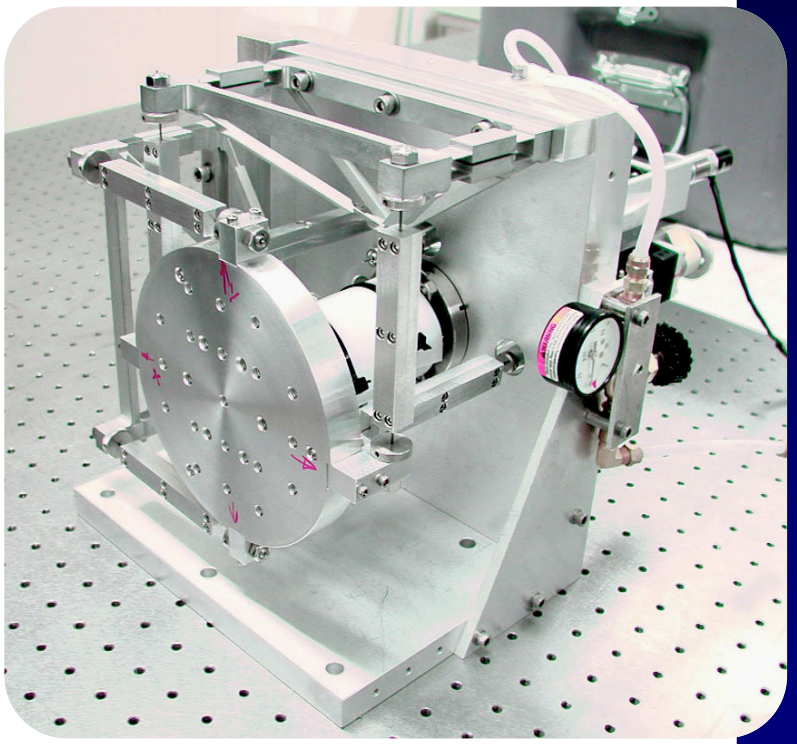
# Precision Flexures (2)



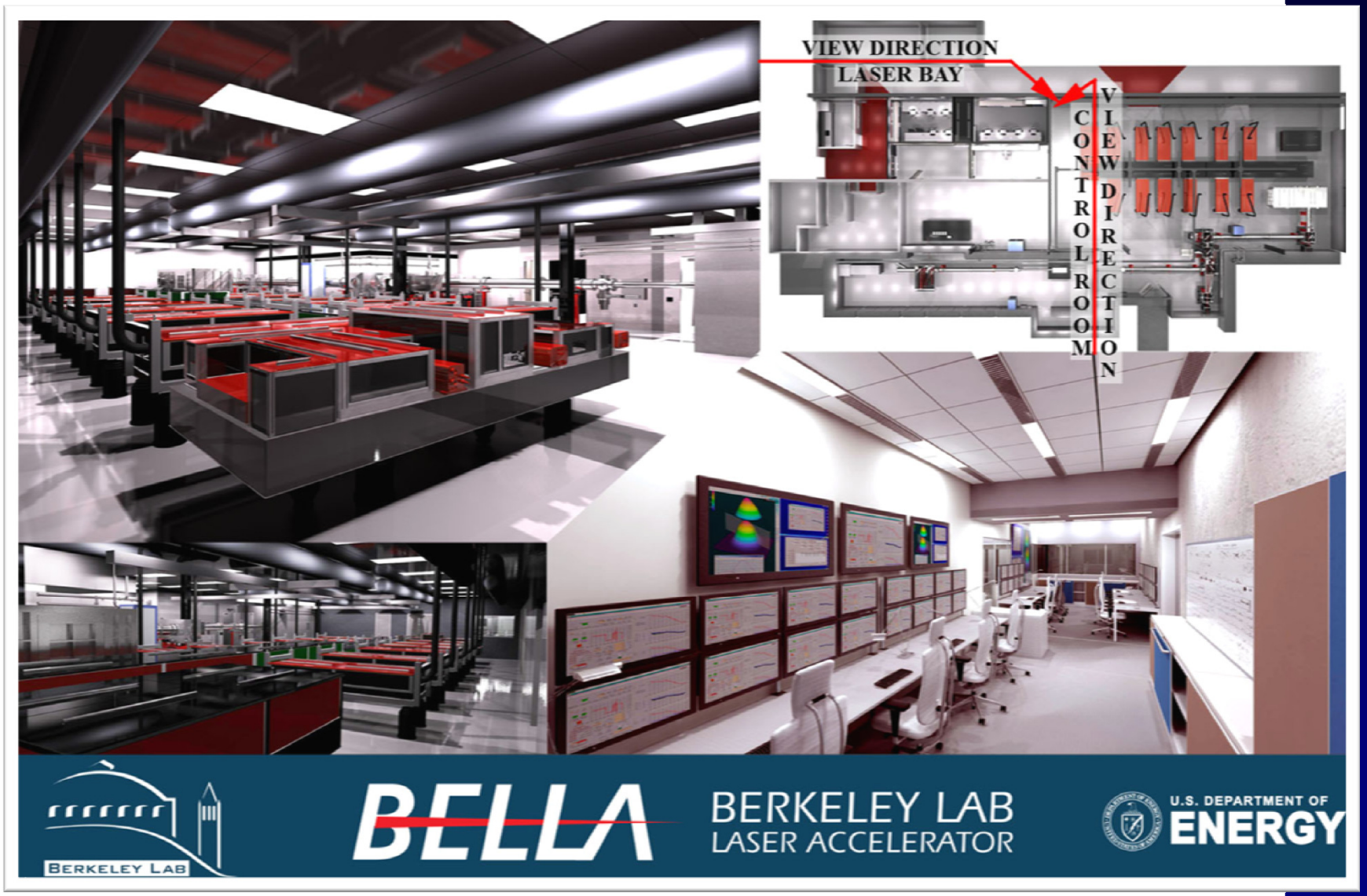

Flexure Based

UHV 5 Axis Sample stage (bottom)



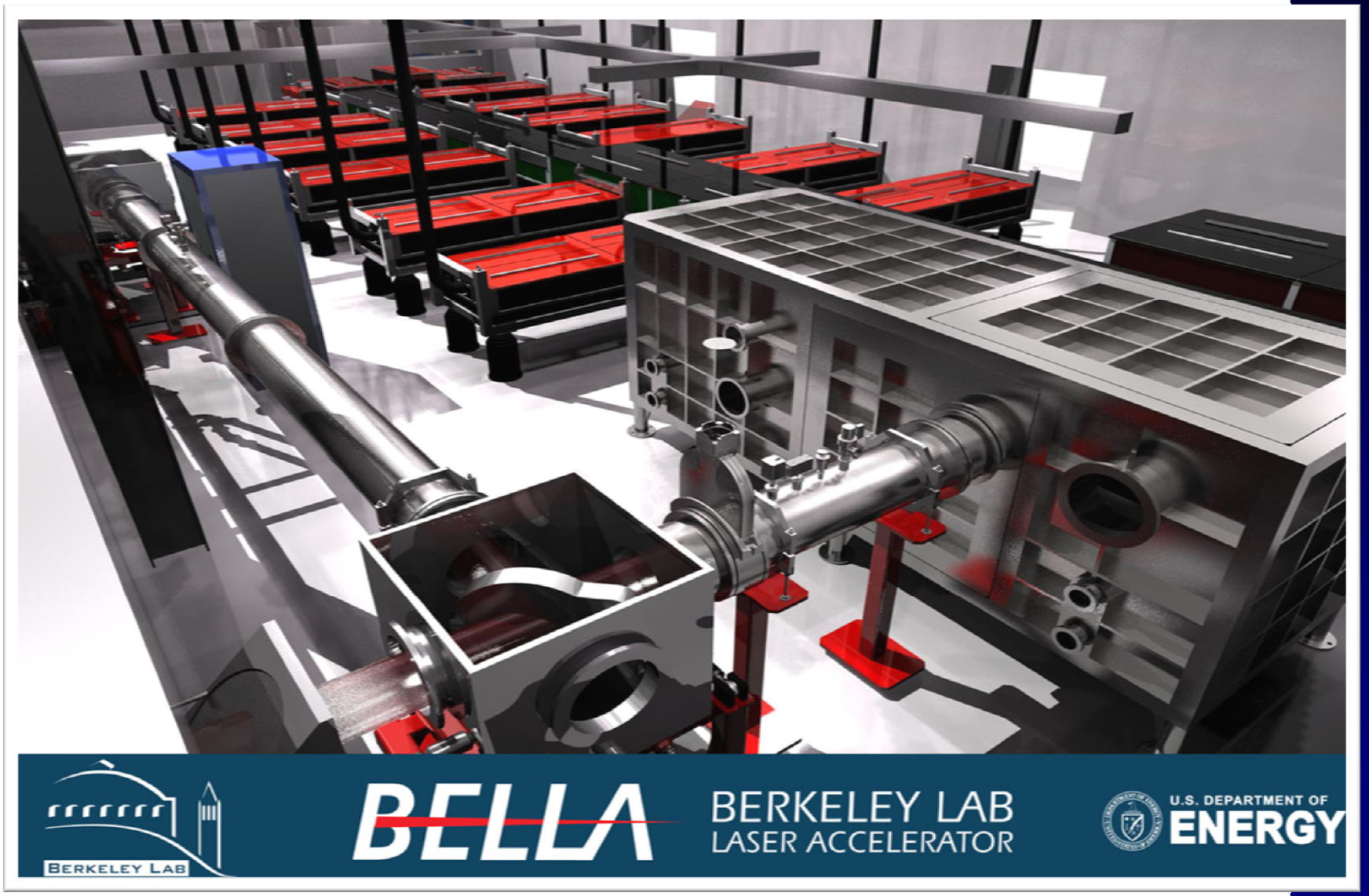
Contact: Ken Chow| KPChow@lbl.gov 

# CA odeling and isualization (1)



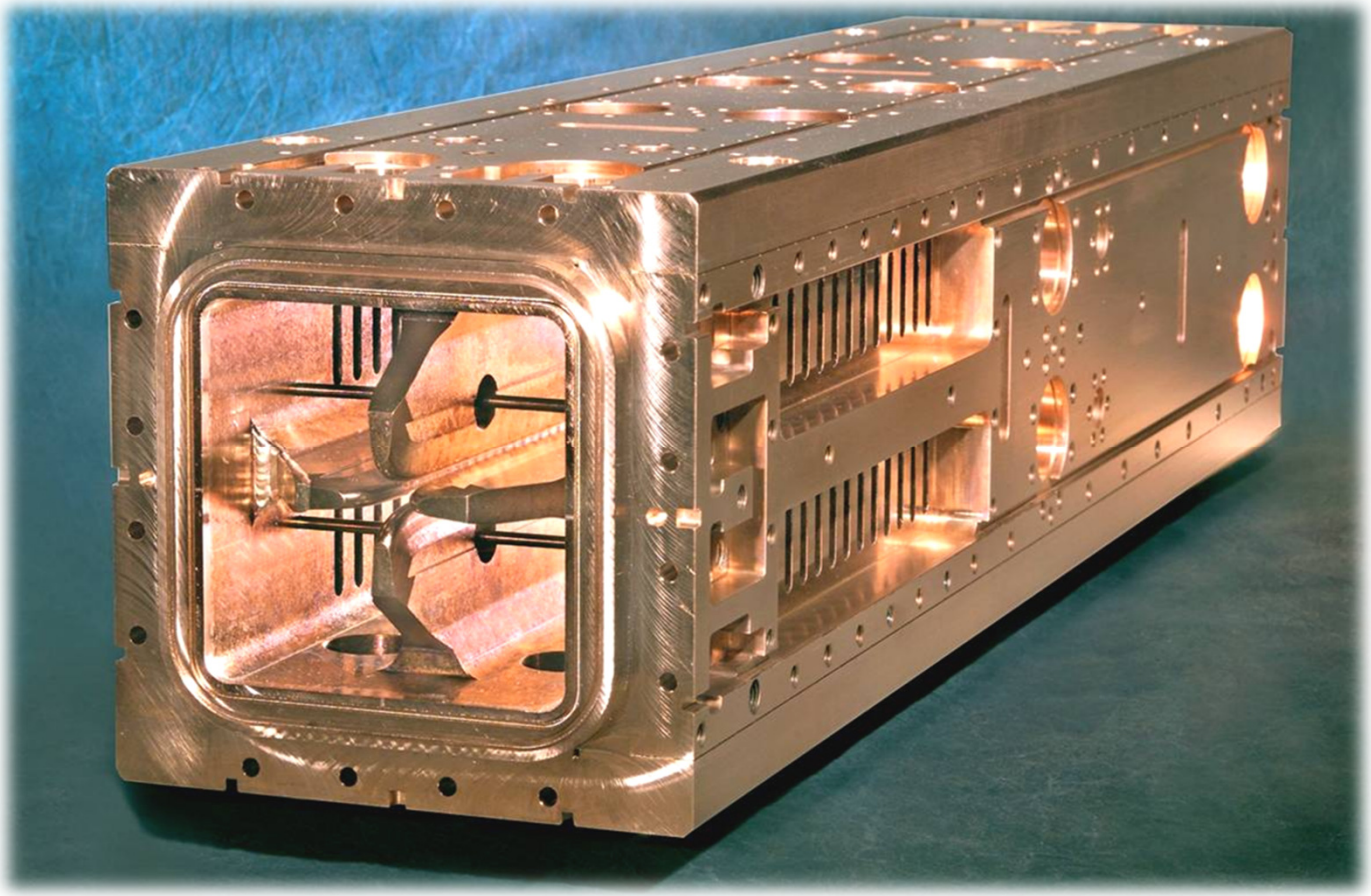

Contact: Rob Duarte| RMDuarte@lbl.gov

# CA odeling and isualization (2)




Contact: Rob Duarte| RMDuarte@lbl.gov

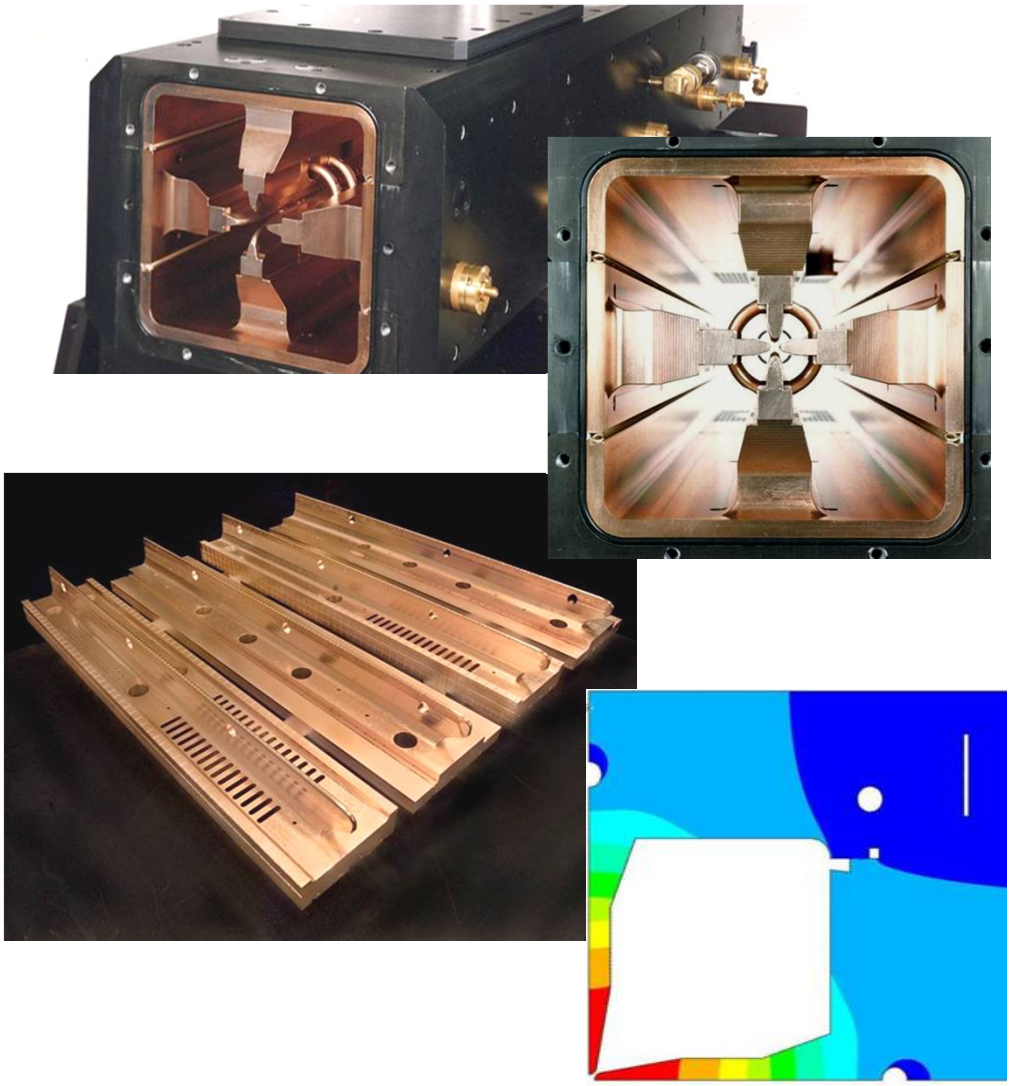
# Radio Frequency Quadrupole Accelerators (1)



- One of four modules of the Spallation Neutron Source (SNS) Front End Radio Frequenbcy Quadrupole (RFQ) designed and built by LBNL

Contact: Steve Virostek| SPVirostek@lbl.gov

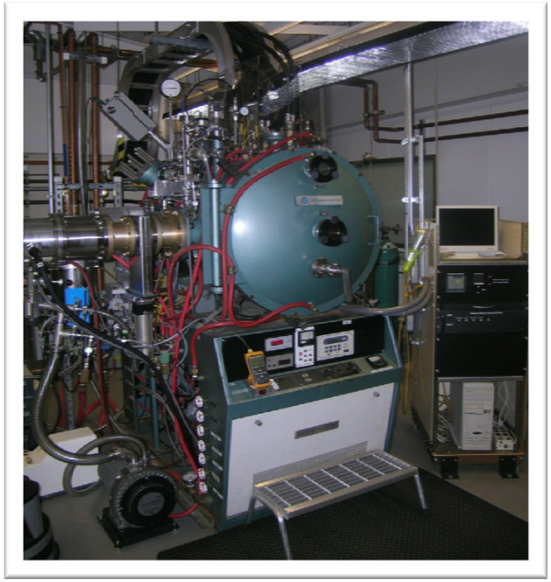
# Radio Frequency Quadrupole Accelerators (2)

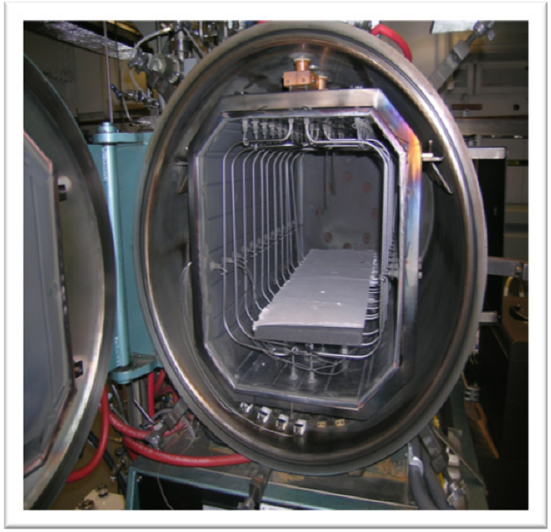


- Developed 4-vane RFQ design and fabrication expertise over 30 years
- Five unique RFQ's built by LBNL for a variety of accelerator projects
- Team of physicists, mechanical engineers and designers now working on two new RFQ design projects
- Key capabilities: beam dynamics design, RF thermal and mechanical analysis, advanced fabrication techniques

Contact: Steve Virostek| SPVirostek@lbl.gov

# Braze Furnace Capabilities

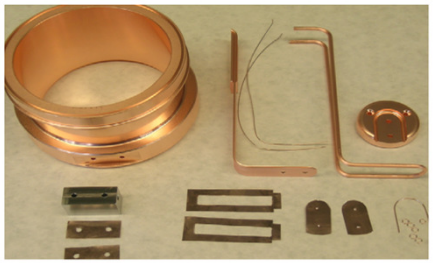




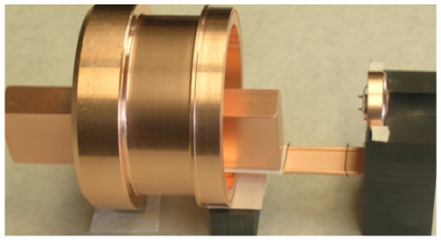
- As a vacuum braze furnace we can attach similar and dissimilar metals with widely different thicknesses together while maintaining strict dimensional tolerances. Brazed components have joints as strong as the parent metal, are vacuum leak tight, clean, and offer excellent stress and heat distribution.
- As a heat treatment facility we can anneal and surface treat parts in vacuum or in an inert gas environment.
- As a vacuum bake out system we can reduce part contamination.
- Furnace maximum temperature is $1200^{C}$
- Furnace base pressure is $1.0 \times 10^{-7}$ Torr
- Furnace hearth plate is 35 x 11 inches and capable of supporting parts up to 220 lbs.
- Programmable heating cycles control part temperatures

Contact: Guy Pulsifer | GRPulsifer@lbl.gov

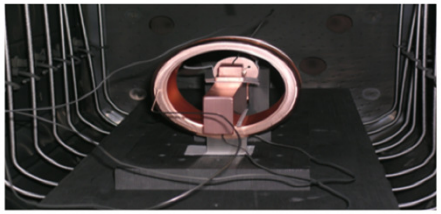
# Examples of acuum Braze



Stainless steel, copper and Glidcop parts with braze filler metal



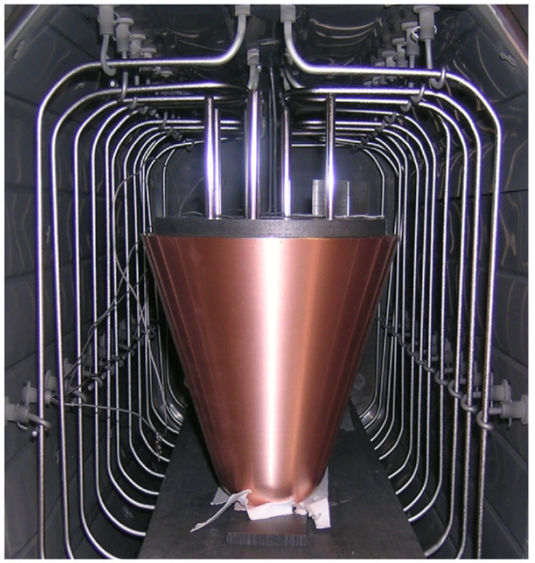
Assembled parts in fixture



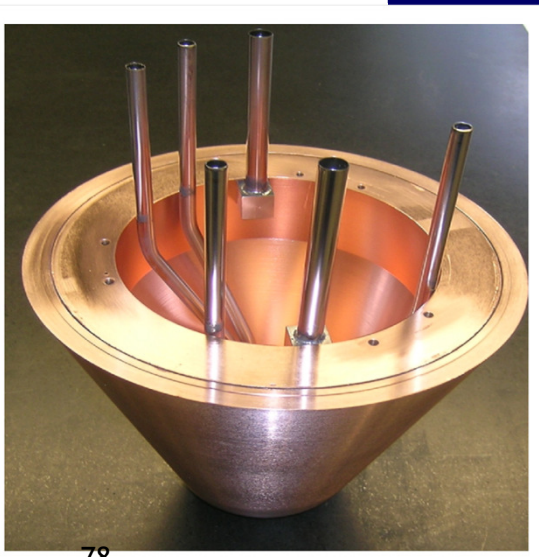
Assembled parts in furnace with thermocouples attached

Brazed RF coupler for FLS injector

FLS injector cathode cone in furnace

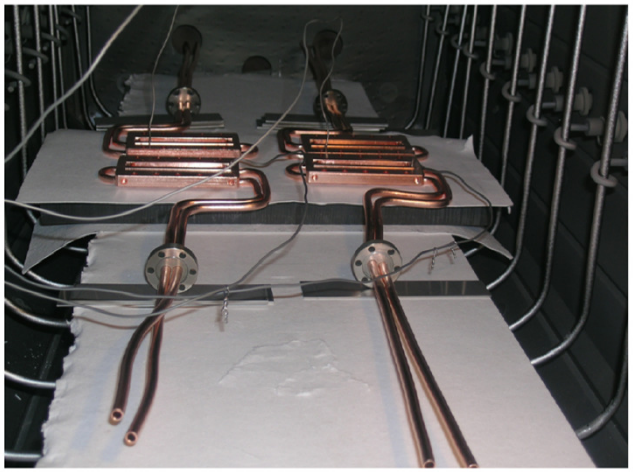


Brazed cathode cone



Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# Furnace Heat Treatment Bake ut

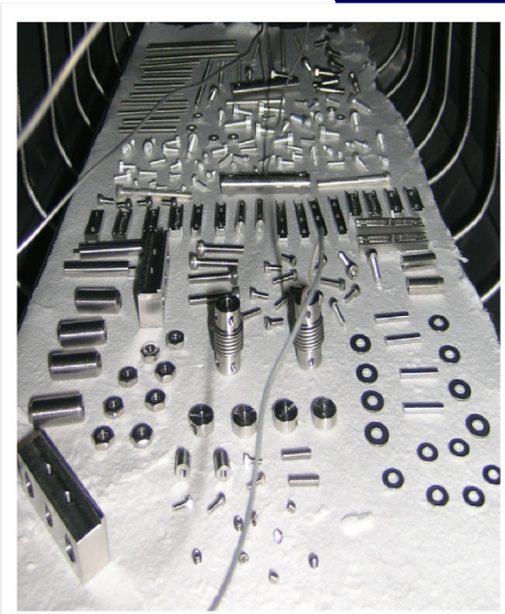


Anneal copper

Vacuum bake out
bellows & viewports

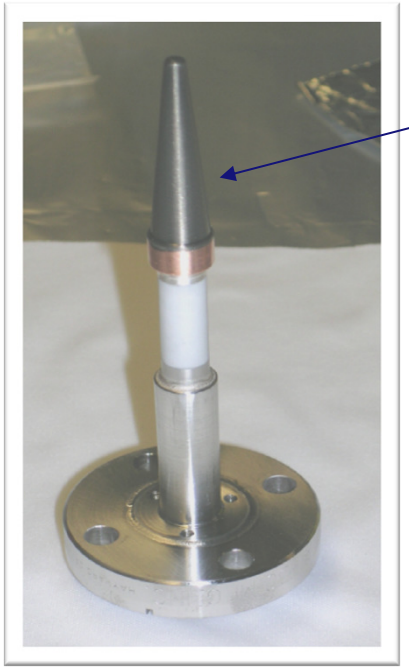
Heat treatment
of quartz tubes

Bake out
vacuum components



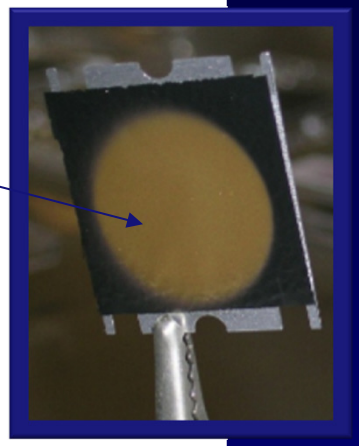
Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# acuum eposition of Films (1)

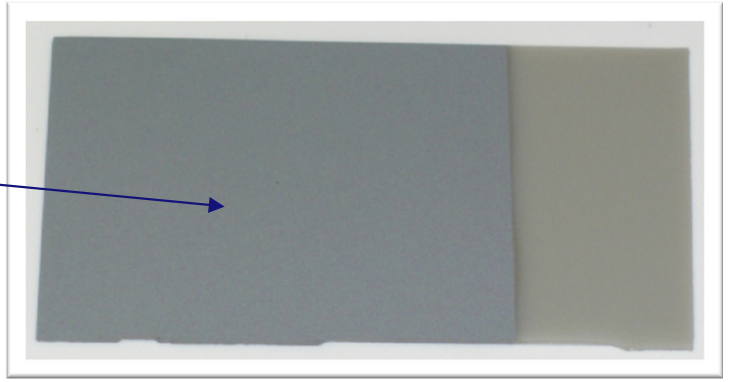


Titanium film deposited on copper cone for tensor neutron generator

Gold film deposited on carbon foil for nuclear target

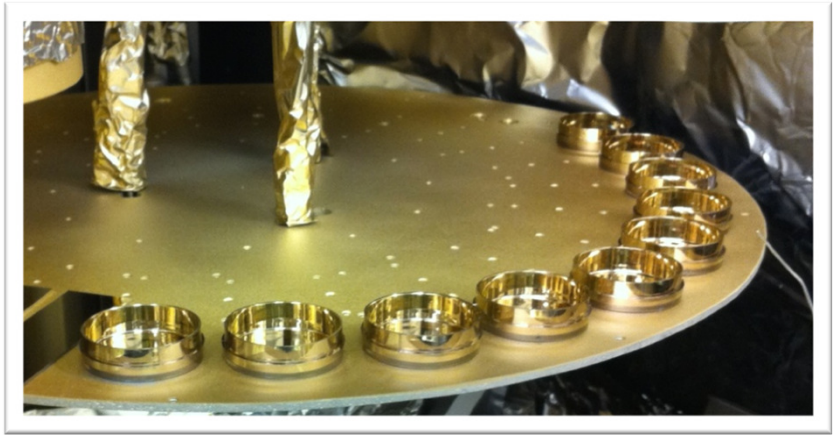


Silicon film deposited on AlN for UV filter on CCD



Contact: Guy Pulsifer | GRPulsifer@lbl.gov

# acuum eposition of Films (2)



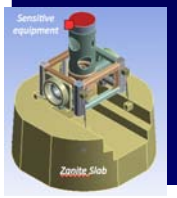
50nm Gold film deposited in petri dishes for cell media

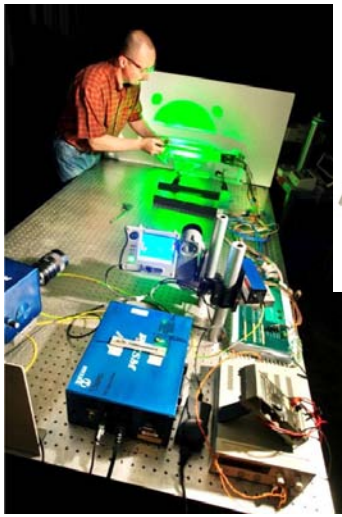
5 micron Pt coating deposit on kapton for heater application

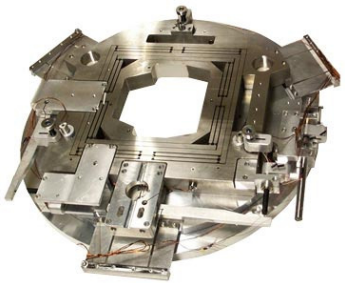
- Vacuum deposition of films- is available for all sciences.
- Vacuum Deposition has deposited many different films for many applications during the past 60yrs.
- Most elements, some compounds, and insulating compounds are deposited by thermal evaporation, e-beam evaporation, or magnetron sputtering techniques.
- Film thickness can range from 1 nanometer to microns.
- Films can cover entire substrate or patterned for the application.
- We tailor the film(s) to meet the application requirements.

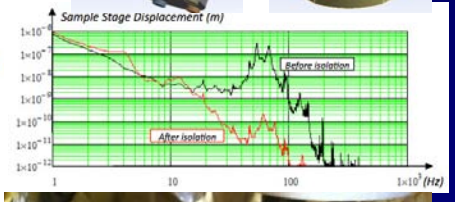
# LBNL Engineering: Summary Capabilities (1)

- Superconducting magnets
- Permanent/hybrid magnets
- Precision mechanisms
- Ultra-high vacuum
- Vacuum deposition
- Mechanical design and instrumentation
- Cryogenics
- Metrology
- Manufacturing Development
- Process Engineering
- Vibration Analysis & Control
- Accelerator RFQ structures
- Composites
- Scientific project management and controls






# LBNL Engineering: Summary Capabilities ( )

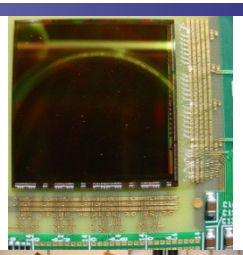
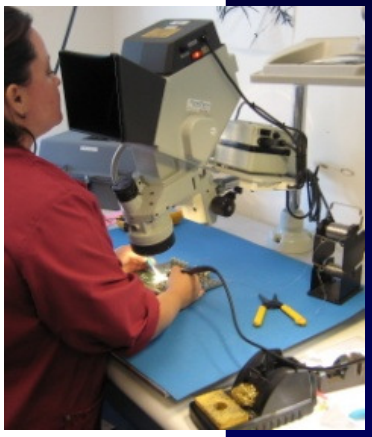
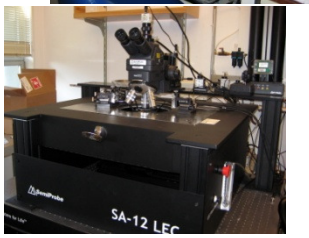
BERKELEY LAB

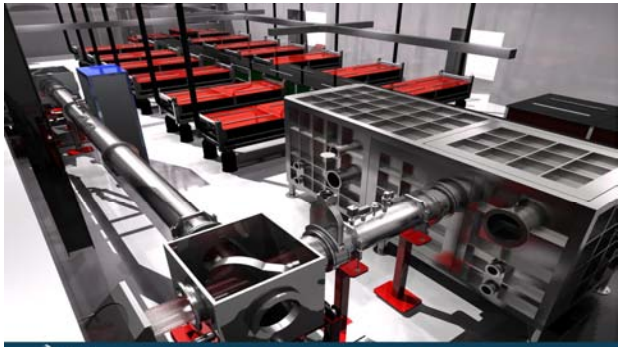
## Electronics & Detector Fabrication

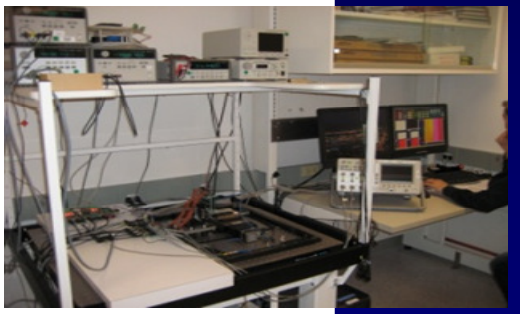
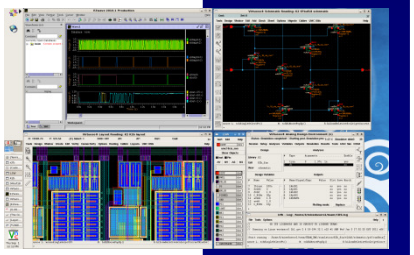
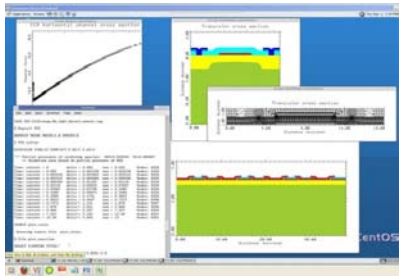
- 150 mm IC Wafer Furnace
- Wire Bonders
- IC Probe station
- Composites Laboratory
- Clean-room Assembly Labs
- IC Test Facilities
- Conventional Electronics Shop
- Monolithic Solid-State Detector Lab
- Photo-Fabrication
- High-voltage test stands
- RF High/Low test facilities

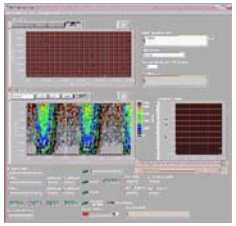
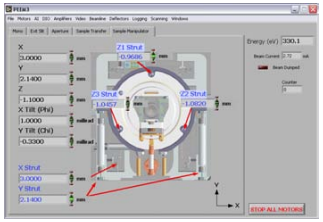
## Software Systems

- High-End Analysis/Modeling
- High-End 3 Dimensional CAD
- High-End Electrical Design
- High-End IC CAD
- High-End Detector modeling tools
- Integrated LabVIEW control systems

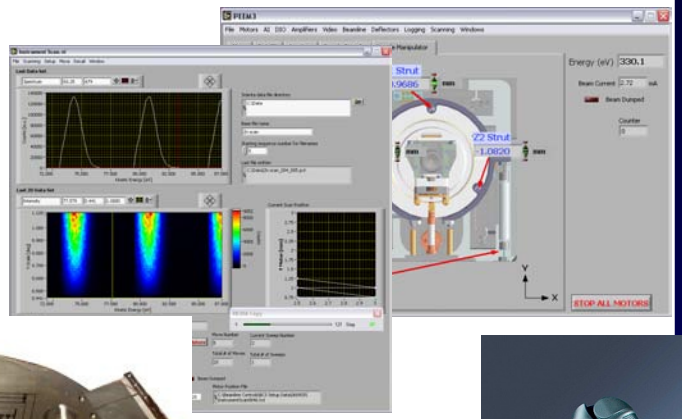


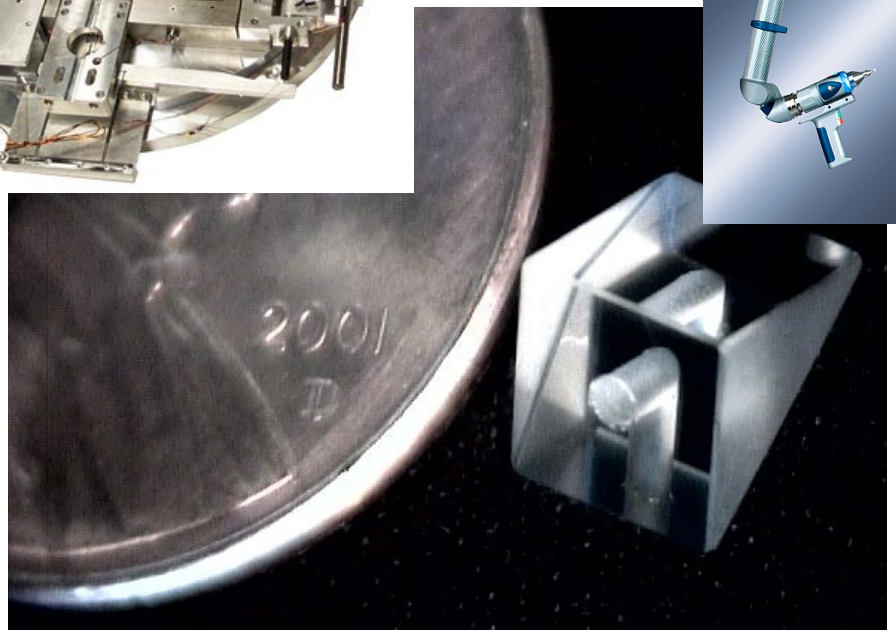




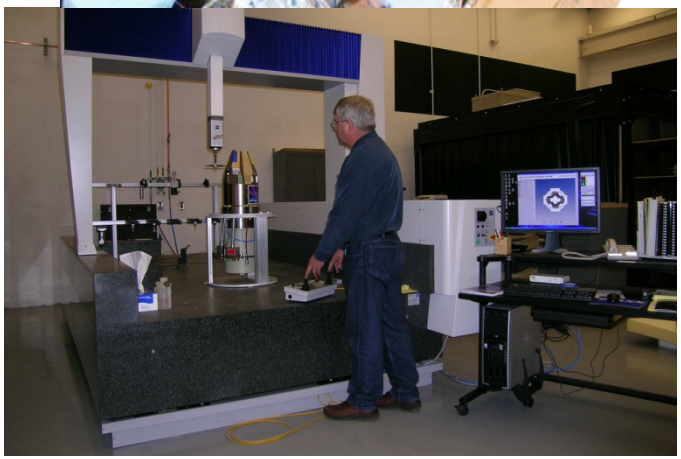
# LBNL Engineering: Summary Capabilities (3)

- Application specific integrated circuits
- Semiconductor detector and instrumentation
- Superconducting detectors and instrumentation
- Controls
- Accelerator feedback
- Accelerator beam controls
- Low level rf
- Composites
- Bioinstrumentation
- Robotic / Systems instrumentation
- Pulsed Power
- fs timing and synchronization
- Scientific project management and controls
- LabVIEW programming / controls





# LBNL Engineering Engagement



**Engineering currently operates with 5 matrix models**

1. Staff who are long-term captive to one division
2. Staff who shift between large projects with long-term commitments
3. Staff who work on about 2 to 3 different projects for one or more divisions with rather long-term commitments
4. Staff who work on smaller, shorter-term projects
5. Staff who work for ED, doing many different jobs within the laboratory (e.g. Machinists)

# y LBNL Engineering esources

- Ability to soften resource fluctuation issues
- Technical and engineering staff keeps closer to state-of-the-art
- Ability to call upon complete scope of LBNL Engineering capabilities/expertise
- Designs/approach consistent with DOE/Lab requirements avoiding costly reworks/modifications
- PI's concentrate on science and development not personnel management
- Most effective when engaged early

# Summary

- LBNL Engineering provides Berkeley Lab an *unfair* scientific advantage
- Leverages laboratory-wide resources in support of scientific programs / projects
- The Engineering Division is to be an institutional catalyst helping enable multi-disciplinary collaborations and advancing the state of the art in Scientific R&D
- LBNL Engineering helps pioneer, engineer, build and integrate the next generation of complex breakthrough instrumentation that will be required to advance world-class scientific exploration and discovery

# Where to go from here?

- Contact us if you need engineering, project or technical assistance on proposal preparation
- More in depth technical seminars, brown bags and exchanges between EETD and LBNL Engineering
- Engineering, technical, or fabrication resource needs for programs
- LBNL Engineering will seek collaboration with EETD on improving sustainability of accelerator and detector technical systems

General Contact: engineering@lbl.gov | 510.486.4200